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The Kimberley Project.

Adapted from an address to the W.A. Branch, Australian Chemical Institute, 22nd November, 1944, by L. J. H. Teakle.

A. THE KIMBERLEY PROJECT IN THE LIGHT OF EARLY AUSTRALIAN DEVELOPMENT.

Australian development by the European commenced in 1788 when Captain Phillip founded a penal settlement in the vicinity of the present metropolis of Sydney. Later there were settlements in Tasmania (1803), Albany (1826), Perth (1829), Melbourne (1834) and Adelaide (1836).

In each case progress in the early development of the settlement was very slow and difficult. The natives had worked out a way of life adapted to the Australian conditions, but the European in the strange Australian environment floundered for many years, suffered untold privations and was often near starvation when supply ships failed to arrive or were not available on account of the unsettled political situation in Europe and North America. Seasonal variations were responsible for gluts when the seasonal conditions were favourable and famines at other times.

Australia did not appear attractive to the European, or, as a matter of fact, to Asiatic neighbours, such as the Malays, until the opening of the 19th century, when MacArthur's wool impressed the English manufacturers. Later, the discovery of gold in quantity in 1851 attracted the attention of people easily infected by the gold fever. This influx of population resulted in greatly increased demand for agricultural products and gave the impetus for the initiation of a vigorous agricultural programme. Unfortunately agriculture did not prosper in the new country until superphosphate was introduced about 1880. Since that time prospects have improved and Australia has become one of the great exporting countries of the world.

With the establishment of an Australian agriculture, two schools of thought developed: one, the illimitable potentialities school; the other, the school of pessimists. Of these, the first has been the more dangerous. It is still with us and continues to be dangerous. This school envisages anything up to 200,000,000 people in Australia and teeming millions in our central open spaces. When uninformed neighbours, hard up for *lebensraum*, hear this from people in responsible positions, a political situation develops which contributes to international crises and the initiation of wars.

We need a few of these optimists to lead our thoughts and to stimulate us to investigation, but they need to be harnessed to the investigators and practical men who can translate vision into practice.

The pessimists are always with us. In their eyes, the difficulties and failures in Australian development have been most apparent. Their value lies in the stimulation derived from their pessimism. In their proper perspective they serve like a good opposition in Parliament, but Heaven help us if they ever get into power.

The facts are that Australia can support a considerably increased population and needs more people to effect further development. However, the physical environment, particularly rainfall, provides a limitation and it is probable that 20 million people is a more reasonable objective than 200 million.

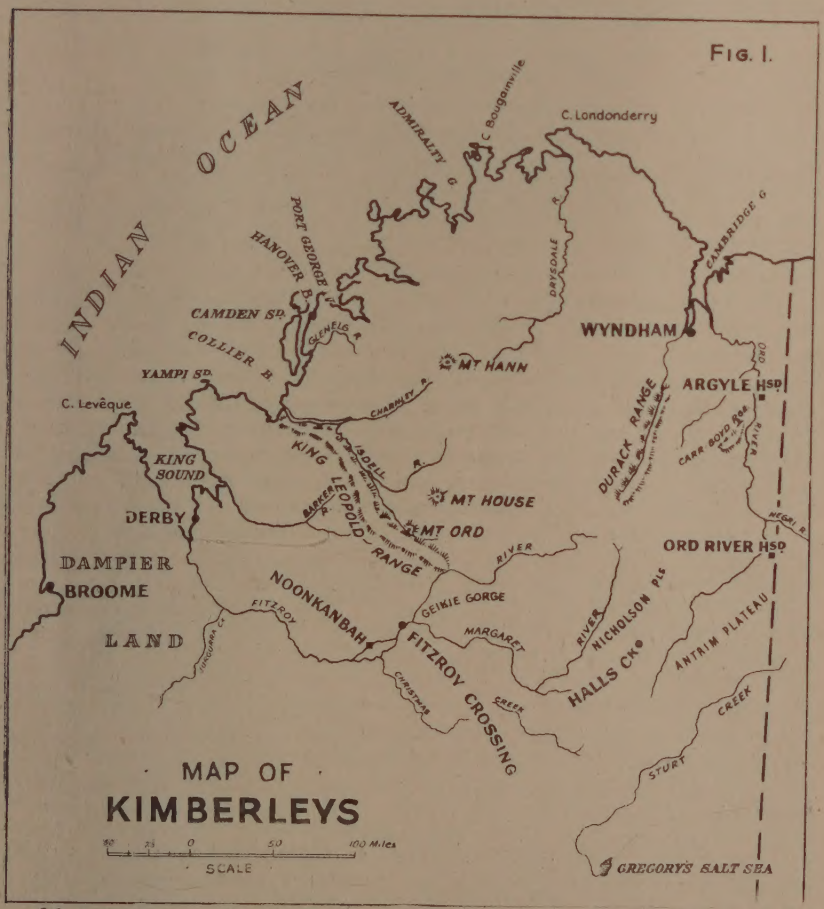
Governor Stirling appeared to belong to each school at various times. The Western Australian Year Book 1902-04, 13th edition, prepared by Malcolm A. C. Fraser, on page 14 reports the conclusions arising from Captain James Stirling's visit in March and April, 1827, when in command of H.M. Frigate "Success." Acting under instructions from Governor Darling in Sydney, Stirling and Mr. Charles Fraser, a botanist located in New South Wales, visited the Swan River, Geographe Bay and King George Sound. Both Stirling and Fraser were greatly impressed and Fraser's entry in his journal indicates that he judged the Swan country to be superior to New South Wales east of the Blue Mountains, on account of the better soils, the lighter clearing and the abundance of fresh water and moist soils. In view of these glowing reports, Governor Darling recommended settlement at the Swan and James Stirling was commissioned to form the settlement in 1829. A few years later, Governor Stirling (in Despatch No. 218 of 15/10/1837) was far less enthusiastic regarding the soils. He says, "The surface of the country generally is covered with those substances which are technically called earths in contra-distinction to soils. Of the latter, as far at least as regards those of a vegetable origin, a very small portion exists and that only on moist grounds. The extreme drought of the climate and the summer conflagrations appear to prevent the growth of succulent plants as well as any great accumulation of soil from decayed vegetation. But although the country is not remarkable for the richness of the soil, it is favoured in other respects to farming purposes. I am under the necessity of saying that a very large proportion of its surface, extending probably to three-fifths of the whole, is poor and comparatively unprofitable and unlikely to be cultivated or to yield any return except in timber until a dense population and low wages, aided by abundance of cattle, bring it into use."

The history of Australian agriculture is a record of success achieved only after unforeseen difficulties had been surmounted by determination and ingenuity, often in the absence of adequate knowledge and proper tools. Even in the last 25 years land settlement projects have involved serious financial losses to the community and personal hardships and disappointments to the settlers.

Future projects will be no less difficult than the past. In fact, it is probable that all areas most tractable to development under the methods of the past have been more or less occupied and further progress will be dependent for success upon the full use of all aspects of modern science and engineering.

When the Kimberley project is viewed in the light of land settlement history in Australia and the recent progress in science and engineering, it appears less formidable than it did even a decade ago. It is certainly far less formidable to us

than was the establishment of a community at Port Jackson in 1788 or at the Swan River in 1829. A number of factors will determine the practicability of developing the Kimberleys: the suitability of the soils, crops and stocks adapted to the climate, water supply, communications, markets, political and social questions, and last, but not least, the ability of the white Australian to live and work and to raise a healthy family under the climate, perhaps modified by modern engineering aids.



Of these factors, the simplest are the agricultural and engineering. Already the Western Australian Government has commenced investigations and engineers of the Public Works Department, surveyors of the Department of Lands and Surveys and scientists of the Department of Agriculture are engaged in making a thorough survey of the prospect. There is no doubt that no avenue of enquiry will be missed in the endeavour to ensure a sound basis for whatever decision is made.

This is of extreme importance, as any hasty conclusions may result in a failure which would damn the development of this portion of the continent for many years and may result in untold hardship to those who elect to take part in an ill-

considered programme. If the enquiries result in a decision to develop the Kimberleys, there is no doubt that the findings can be extended to include a large amount of the Northern Territory which constitutes, with the Kimberleys, a natural region of Australia now divided by State boundaries. It is pleasing to note that the Commonwealth authorities are interested in the enquiries of the State officers. Members of the Rural Reconstruction Commission have visited the area and the Commonwealth has assisted research work by the seconding of a soil survey officer to the Department of Agriculture party.

B. HISTORICAL.

Let us cast a brief glance at the history of the Kimberleys. Prior to 1800, the north had been known to the Portuguese, the Dutch and some English navigators, but apart from its use in time of trouble, they found the country uninviting, if not definitely repulsive. They have left their names and in a few cases inscribed plates and some wrecks. We recall the names of Pelsart, Dirk Hartog, Houtman, Dampier, Torres and Tasman. Of more importance were the later expeditions. Of these a few warrant mention.

1. *Grey and Lushington,* 1837-39.—After the establishment of a settlement in southern Australia, the British Government decided to explore the north. The first expedition was led by Lieutenant George Grey and Lieutenant Lushington, under a commission from Lord Glenelg, then Under Secretary of State for the Colonies. Grey and Lushington sailed to the Cape of Good Hope in the sloop "Beagle." On arrival in South Africa they chartered the schooner "Lynher" of 140 tons for the work. In this small vessel they sailed for Hanover Bay, which was reached on 3rd December, 1837. Their chief assignment was a search for a river flowing into the north from the interior, the existence of which was suggested by the lower reaches of a number of the northern Kimberley streams.

This expedition looked further than mere exploration and brought cotton and other plants and seeds with the object of forming a garden. Specimens of native material were collected, but their explorations were limited owing to the difficult conditions, largely due to the wet and heat of the season. It is interesting that Timor ponies were brought in for use on the explorations. In comparison with the area only small distances were travelled; the Glenelg River was discovered and named and Grey was greatly impressed by the possibilities for good harbours, of which Port George IV., Hanover Bay and Camden Sound were mentioned. Grey also noted that the patches of good pastoral country were generally associated with basalt flows and there were occurrences of fertile alluvial valleys. The deep, impassable ravines of the rivers and the rugged nature of the prevailing sandstone country rendered travel and communications difficult, but even so, Grey waxed eloquent over the beauty and fertility of the country, the pastoral possibilities and prospects for growing cotton, sugar, indigo and rice.

Unfortunately, Grey was speared by natives on 11th February, 1838, and his injury forced a return to civilisation at Perth before he had completed his enquiries.

2. *Captain Wickham and Captain Stokes,* 1838-41.—These explorers followed the "Lynher" in the "Beagle" and explored and mapped the north and north-west coasts. They discovered the Fitzroy River in March, 1838, and were greatly impressed by the grasslands of the broad valley. They named King Sound. From the Kimberley area they proceeded eastward and in 1839 discovered and explored the Adelaide and Victoria Rivers. Like Grey, Stokes was speared and his injury

compelled the party to return to civilisation. It is of interest that the "Lynher" and the "Beagle" met the Port George IV in April, 1838, in the course of their exploration work.

3. *A. C. Gregory*, 1854.—In company with Baron F. von Mueller, Gregory explored the Victoria River to its source and crossed the desert to Sturt Creek and discovered Gregory's salt sea in Western Australia. A. C. and F. T. Gregory spent several years in the area and were greatly impressed by the pastoral possibilities and the prospects for the cultivation of cotton and sugar. In fact, there was a proposal at this time to bring in Asiatics to grow cotton to relieve the shortage brought about by the American Civil War. Fortunately, this proposal was never put into effect.

4. *Alexander Forrest*, 1879.—Probably the most important expedition was that of Alexander Forrest in 1879, whose reports brought the cattle industry. Alexander Forrest travelled from the DeGrey to Dampier Land, up the Fitzroy, where he found the King Leopold Range to be impassable, eastward along the Margaret River to the Nicholson Plains and the upper Ord and Negri Rivers. Sickness and hardship compelled him to shorten his investigations and make for the telegraph line in the Northern Territory, but he estimated that he had discovered 25 million acres of pastoral country, including the Nicholson Plains, which he described as "the finest part of Western Australia that I have seen."

Forrest's report directed the attention of pastoralists to the area and attracted, particularly, Queenslanders. Among the first to arrive were the Duracks and and Emanuels in the early 80's. Their herds multiplied rapidly and spread westward over much of the Kimberley country where high class grasslands, well watered by streams and pools, were to be found. The range country was largely neglected on account of difficulties in communications.

In the decade following Alexander Forrest's exploration, a number of prominent explorers visited the Territory. Most prominent among these were John Forrest, Surveyors J. S. Brooking, H. F. Johnston, G. R. Turner and G. J. Walsh and Geologist E. T. Hardman in 1883-84, and H. F. Johnston and C. Y. Nyulasy in 1885. Hardman discovered evidence of gold. A little later, an expedition led by Charles Hall and P. Slattery located a payable find at Hall's Creek in 1884, as a result of an expedition from Yeeda Station on the Fitzroy.

5. *Frank Hann*—1896-98.—Towards the close of the century, Frank Hann, a colourful member of the Queensland squatters, whose property lies in the Gulf of Carpentaria section, organised an expedition and did valuable work in the Kimberleys and other parts of the State. Hann appears to have had an incurable wanderlust and has left his trails over much of little-known Australia. Of particular importance was his crossing of the King Leopold Range barrier which had frustrated Alexander Forrest. In association with the police officer at Derby, Hann found a pass at the head of the Barker River and opened a way to the Isdell River and Mt. House country, some of the best watered pastoral areas in the country.

6. An important expedition led by *F. S. Brockman* in 1901, included *A. Gibb-Maitland and Dr. House.* Mr. Gibb-Maitland, later Government Geologist, is well-known to Western Australians and has done outstanding geological work in this State. This expedition discovered six million acres of rich basaltic pastoral country between Wyndham and the Charnley River.

7. The *Easton Expedition* examined the western and northern portions of the Kimberley area in 1921. The exploration showed that the country was largely

of a sandstone nature, well watered, very rugged and difficult of communications. A sketch map was drawn indicating the location of areas of grasslands associated with basalt flows which constituted the best pastoral country.

Mr. C. A. Gardner, the present Government Botanist, accompanied this expedition.

These early expeditions travelled largely on foot and with pack animals, and the 1944 explorer, equipped with all modern machinery, marvels at their accomplishments. The present expedition can make use of motor transport of various types and is able to maintain communications by means of pedal wireless and telegraph. A rapidly improving air service enables distances taking days by road to be covered in a few hours. By means of air photography exploration work is simplified and accurate surveys covering thousands of square miles can be completed in weeks instead of years.

Summing up, these expeditions, together with the experience in the development of the pastoral industry, have established a number of important points to be remembered in any consideration of the Kimberley country:—

(a) The rugged topography makes communications difficult. This may be relieved greatly by modern air transport and the use of wireless telephony.

(b) In the Kimberleys, which covers 80 million acres, there are considerable areas of good pastoral country. At present the stock population includes something under 500,000 head of cattle and about 300,000 sheep.

(c) The geologists and miners have established the occurrence of important minerals, and there are reports of good prospects for oil.

(d) For about six months of the year the climate is unattractive for white people and any white settlement would have to make provision for visits to the southern districts in order that the health and vigour, particularly of women and children, could be maintained. The institution of air-conditioning in the houses and modern refrigeration may change the outlook with respect to these settlement problems.

(e) The variability of the rainfall renders intensification of production by extensive agricultural methods virtually impracticable. With the institution of irrigation, the prospects for intensive agriculture, possibly as an adjunct to the pastoral industry and for the production of horticultural crops, warrant careful investigation and there appears to be a reasonable chance for success from the agricultural viewpoint.

(f) Most apparent is the complete dependence of sound development in the future on careful research work to develop new methods of land utilisation, a radical change in the management of the pastoral country, much of which is now showing serious signs of deterioration, and the provision of adequate communications, largely by roads and air.

The future outlook of any developmental programme in the Kimberleys must be forward.

C. GEOGRAPHICAL.

The Kimberley area lies within 14°S. and 19°S. latitude and is thus within the tropics. (See Fig. 1.) Other continents in these latitudes exhibit conditions showing many points of similarity. Of these the Sudan in Africa appears to be the most similar. In consequence it is considered that valuable assistance in

arriving at a decision with respect to a developmental programme in the Kimberleys and similar parts of Australia can be obtained from a study of the Sudan, particularly in the neighbourhood of Segou in French West Africa, Northern Nigeria and Khartoum. Unfortunately the variability of the rainfall in the Kimberleys appears to be much greater than in the Sudan, a fact which seriously limits agricultural extension when unaided by irrigation.

The Kimberleys, which cover an area of 125,000 square miles, or 80 million acres, form part of a province in the continent of Australia which extends into the Northern Territory. It is considered that any success in the Kimberley project offers a solution to the problems of much of the Northern Territory. The Northern Territory Development League, under the chairmanship of Mr. E. J. Connellan, is investigating a developmental programme and is anxious to collaborate with any other authorities interested in the same ends.

D. GEOLOGY.

The geology of the Kimberleys is much more interesting and complex than in the southern part of Western Australia. Besides the granites and gneisses, there is a range of rocks from extremely ancient to relatively modern. The chief rocks may be grouped as follows, commencing with the youngest:—

1. *Tertiary.*

(a) In tertiary times there appears to have been a certain amount of volcanic activity. Leucite basalt necks may be observed in the vicinity of Noonkanbah.

2. *Mesozoic.*

(b) Jurassic sediments forming the Mt. Erskine series are prominent in the same areas.

3. *Palaeozoic.*

(c) Devonian limestones are also prominent in the west Kimberleys. The Fitzroy River cuts through these limestones at one site known as the Giekie Gorge, which would be worth investigating as the site for a dam if the lower reaches of the river were proved suitable for irrigation.

(d) Permian sandstones, shales and glacial tills are prominent in the eastern Kimberleys where they give rise to considerable areas of sandy soils such as the cockatoo sands.

(e) Two horizons of Cambrian rocks are important:—

i. The upper Cambrian limestones and mudstones cover a considerable area in the upper Ord River valley. Soils associated with these formations have proved exceptionally liable to erosion.

ii. The lower Cambrian basalts in the same area are associated with important areas of grassland.

4. *Pre-cambrian.*

(f) Amongst the pre-cambrians, three groups of rocks are recognised:—

i. The Nullagines, largely more or less horizontally bedded sandstones and shales which cover a large proportion of the central highlands.

ii. The Mosquito Creek series of the Archaeozoic period which are highly metamorphosed and contorted sandstones, quartzites, schists, etc. These are exposed at the periphery of the tableland and are important near Fitzroy Crossing, Hall's Creek and in the Carr Boyd Range, through which the Ord River has cut a gorge suitable for the building of a dam.

(iii) Granites are exposed where erosion has removed the ancient sediments.

A curiosity of the Argyle area is an occurrence of a banded mudstone of Cambrian age called Zebra stone.

E. PHYSIOGRAPHY.

The Kimberley area may be described as a low dome, or conoplain, capped largely by the Nullagine sandstones interbedded with basalts, fringed on the south-west by the Fitzroy valley, on the south by the desert, on the south-east by the Antrim Tableland of Cambrian basalt, and the east by the Ord River system. On the north a rugged coastline has been developed where the Nullagines meet the sea. Outstanding ranges associated with the central dome are the King Leopold Range on the south-west and the Durack Range on the east. Prominent points are Mt. Ord, 3,050ft., in the King Leopold Range, and Mt. Hann, 2,800ft., in the tableland proper.

Throughout the tableland one observes a series of huge escarpments and innumerable rivers commonly confined by gorges cut in the sandstones. The rivers radiate from the central highlands, and along the northern coastline the gorges, usually deep and with perpendicular sides, open out to the coast. On the south and east the rivers, on leaving the tablelands, have developed broad flood plains as exampled by the Ord, the Margaret, the Lennard and the Fitzroy. Similar physiographic features are observed to the east on the Keep River, the Baines and the Victoria Rivers. It is on these flood plains that an opportunity is afforded for irrigation, provided the peak floods during the wet season, which are usually of a few days' duration, may be controlled by appropriate engineering installations.

F. CLIMATE.

The climate is of the monsoonal type, that is, under the continental influence in tropical latitudes. The winds in the hot season bring rain over a short period ranging from three to five months, but the rest of the year is dry.

1. *Rainfall.*

Over much of the Kimberleys the rainfall ranges from 20 to 40 inches per annum, and is confined largely to a four-months period. Examination of the rainfall data over many years indicates that on the average only four months of the year receive two inches or more of rain. Owing to the heat it is doubtful whether a lower rainfall in a month would be of much importance.

The rainy period is generally from November to the end of February, but the months of October and March may experience generous falls. The useful opening rains may commence any time in the October-December period and the finishing time is almost as variable.

Not only is the commencing time and the quantity of the rainfall from year to year very variable, but during the wet period it is distributed in a series of short wets rather than as a season of more or less continuous wet weather. During these short wets, when 10-15 inches may be received in the course of as many days, the rivers run bankers. The average period is generally short and the level

diminishes rapidly when the rains stop. Occasionally very heavy rains are experienced and as much as six inches in a day has been recorded at some stations. Between these wet periods the weather may be hot and dry for as much as several weeks.

2. *Temperatures.*

With respect to temperatures, the seasons may be divided into three:—

i. Mild temperatures in May, June, July and August, when the thermometer seldom rises above 90 deg. and the humidity is low. Night temperatures are bracing and frosts occur on the highlands. During May and August the temperatures are higher, but the conditions are not unpleasant.

ii. The wet humid period of November to February.

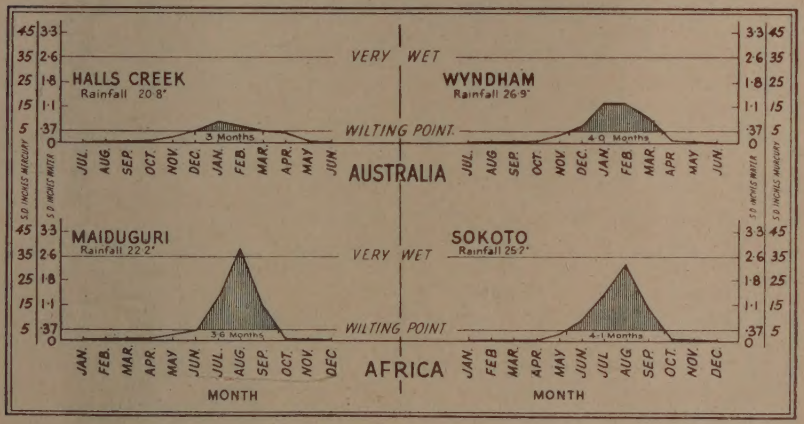


Fig. 2.

The precipitation; saturation deficit ratio gives an indication of the wetness and reliability of the rainfall. The diagram shows the advantage of the Nigerian Stations.

Note.—The columns on the left and right of the figure marked "S.D. Inches of Mercury" and "S.D. Inches of Water" are the Precipitation: Saturation Deficit ratios and should read:—

$$\frac{\text{Precipitation}}{\text{S.D. Inches of Mercury.}} \text{ and } \frac{\text{Precipitation}}{\text{S.D. Inches of Water}} \text{ respectively.}$$

iii. Intermediate periods including September and October and March and April, which are described as the most trying of the year.

3. *Wind.*

The prevailing winds are the south-east trades of the winter months and the north-west monsoon which brings the rain in the wet or summer months. As the winter winds come across the arid interior they are dry with a relative humidity of about 40 per cent. Unlike the comparable winds of the Sudan, which cross the Sahara, they carry little dust except that picked up from local eroded areas, and are far less desiccating. The summer winds are moist, the relative humidity being 65-70 per cent., and are responsible for the seasonal rains. They reach their maximum intensity and constancy in January and February.

With respect to agriculture, a combination of the rainfall and temperature factors is of utmost importance. Various methods have been suggested to represent this combination, but none is completely satisfactory. Perhaps the best available

in the light of scanty meteorological data for the area is the ratio between the rainfall (P.) and a figure expressing the dryness of the air. The dryness of the air is conveniently expressed as the saturation deficit (S.D.), which is the amount of water in inches which would be required to saturate the atmosphere at the average temperature. Thus, the P./S.D. ratio is simply the relationship between the actual rainfall of the period and the amount of water which would be needed to saturate completely the atmosphere. Obviously, the day to day value of this ratio is of importance to the growing plant, but for convenience we can consider the monthly ratio as adequate for a fair judgment. When the conditions vary so much during the year, the ratio on the annual figures, the "Meyer ratio" as it is called, is of little significance. Consideration of the available data suggests that the monthly P./S.D. must exceed 0.37 for the conditions to be moist enough for the growth of ordinary plants, *i.e.*, above the conventional wilting point. When the ratio exceeds 2.6 it is considered to be very wet.

Monthly P./S.D. ratios have been calculated by Prescott* for a number of Northern Australian stations and two of these, together with Nigerian stations of a similar rainfall, are shown diagramatically in Figure 2. The height of the line and the area of the hachure above the wilting point line are measures of the wetness during the season. Undoubtedly the contrast between the Northern Nigerian and Australian stations accounts for the highly developed agricultural pursuits in Northern Nigeria, while the Kimberleys under the same seasonal rainfall are confined to pastoral activities.

The development of agriculture in the Kimberleys will be dependent upon irrigation.

During the four months of mild weather, which resembles mild summer conditions in the south, it is possible to do a reasonable amount of physical work without undue fatigue. In other parts of the year, the capacity for work of the southern white man is limited owing to the trying weather.

G. SOILS AND VEGETATION.

A wide range of soils and vegetation associations occurs in the Kimberleys. However, there are only three groups of major importance: 1, The stony, skeletal soils of the ranges and the deep sandy soils; 2, grey and brown heavy soils of savannahs and grasslands of the plains; 3, brown woodland soils of the river flood plains. Minor types include the corridor forests and sandy soils of the small valleys where running water and seepage improves the moisture conditions.

Figure 3 represents an oblique aerial photograph (run 134 L.6) looking north in the Ord River basin in the Palm Spring-Cooee Creek area. Cooee Creek is the tributary in the foreground on the east side of the river. The photograph was taken from the run a few miles south of Argyle homestead. Argyle homestead would occur on the extreme right edge of the photograph, about the middle, on the Behn River, which may be observed east of the Ord River in the middle distance. In the near and middle distance of the photograph, on the west of the river, is the Carr Boyd Range. This figure shows—

(a) Savannah and grassland plain country near the river in the south.

(b) Typical range country to the north on the western side of the river.

(c) Gully erosion and some deep sheet erosion along the Ord River and its tributaries.

*Prescott, J. A.: The Climate of Tropical Australia in Relation to Possible Agricultural Occupation: Trans. Roy. Soc. Sth. Aust. 62 (2), 229-240, 1938.

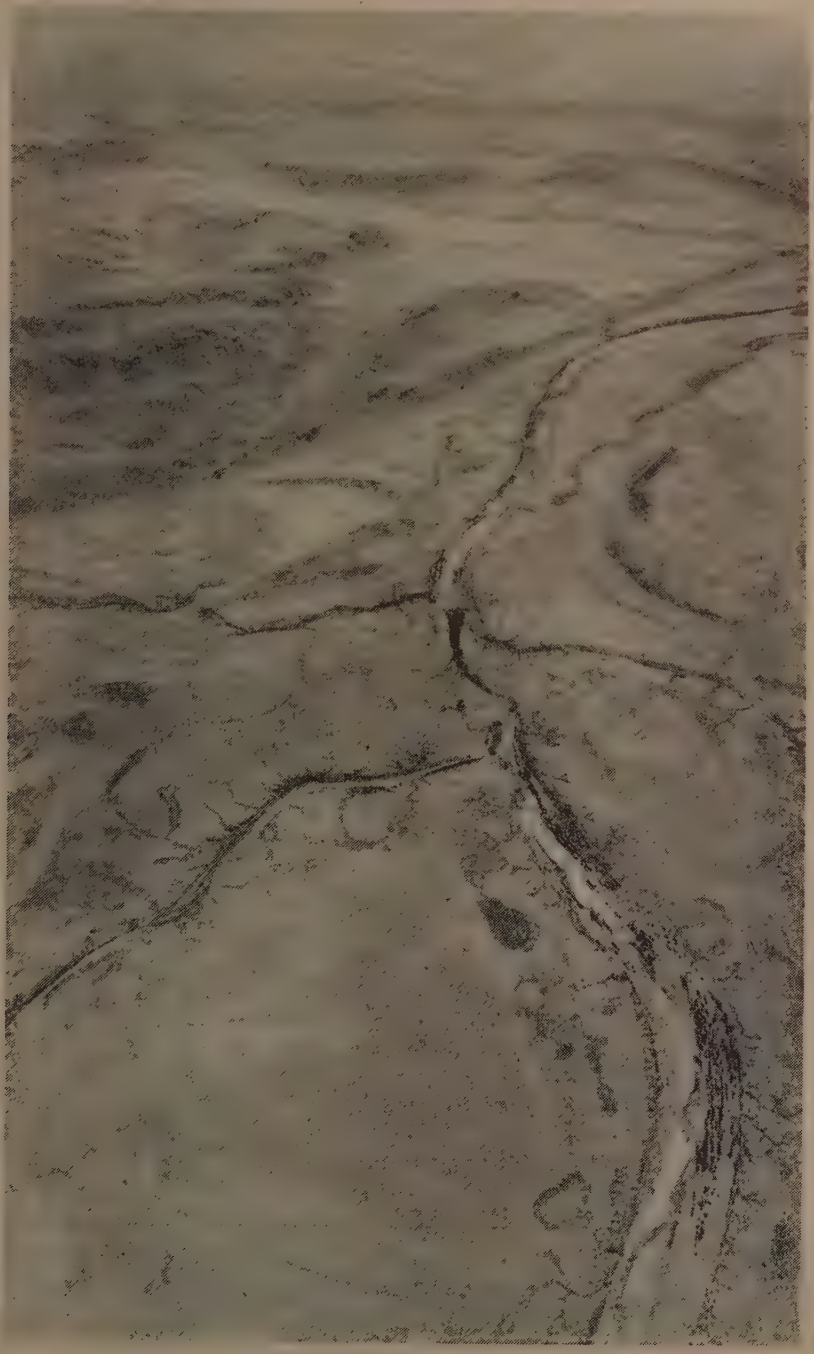


Fig. 3.
The Ord River valley near Argyle.
Note.—1. Carr Boyd Range in upper left. 2. Broad plains in foreground and right.
3. Erosion along the river and tributaries.

1. The great bulk of the area consists of stony, skeletal soils of the ranges and of deep sandy soils such as the cockatoo sands of the East Kimberleys and the pindan † of the West where weathering and accumulation have been more extensive. These soils carry a woodland of small trees, including the eucalypts, spinifex and other coarse grasses. The trees are smaller on the stony range country than on the sandy soils. These types of country are generally regarded as of little value except for extensive pastoral purposes and perhaps, for limited use in association with an irrigation project, for housing and domestic crops.

2. Savannahs and grasslands of the plains: These include the flood plains of the rivers and areas where basalts, limestones and mudstones outcrop and form the basis for the development of favourable soils for the establishment of better grass species. Savannah and grasslands constitute the rich grazing areas of the Kimberleys and will be the foundation of any future intensification of development.

The most important grasses of these areas are Mitchell (*Astrebla* spp.) and Flinders (*Iseilema* spp.) grasses and *Dicanthium*. Unfortunately, in many instances these have been replaced as a result of damage by grazing by a number of other species, such as *Aristida*. The associated trees are chiefly *Bauhinia* and rosewood (*Terminalia* sp). See Figure 4.

It is these soils which have been most closely investigated by the exploration party which operated in the Kimberleys this year. While the laboratory work has not yet been commenced, the conditions suggest that these soils are of reasonable fertility and, given improved moisture conditions, would be suitable for greatly increased agriculture and pastoral production.

The soils fall into a number of groups, some of which have been included in a soil survey carried out by Mr. G. H. Burvill, of the Department of Agriculture.

(a) The dark grey and grey-brown heavy soils of the grasslands and savannahs. These soils and vegetation associations occur on the basalt plains such as are observed on the Nicholson and Argyle and on the flood plains of the Ord River. It is these soils on the flood plain of the lower reaches of the Ord River which constitute the greatest portion of the area suggested for irrigation. This flood plain was apparently laid down in a previous cycle of deposition when the river ponded over a considerable area between Wyndham and the Northern Territory boundary. Mineralogical examination recently carried out by Dr. Carroll, of the Government Chemical Laboratory, indicates that the material has been derived from a variety of geological horizons including the basalts, the limestones and mudstones and the sandstones.

The profile is very uniform with depth and the type extends with a surprising degree of uniformity over great distances. In general the surface to a depth of 4 to 4½ft. consists of a dark grey-brown to dark grey crumbly clay which in the dry period cracks extensively to a depth of about 2ft. as it dries out. This surface appears to be the layer in which organic matter accumulates under a grassland in sufficient quantities to darken the soil colour. Below 4 to 4½ft. the colour is generally brown and the clay material usually extends to a depth of about 7-8ft. A certain degree of layering is observed below this clay and there are deposits of micaceous sandy clay or sandy clay loam and brown clays somewhat different in appearance, suggesting changes in the nature of the silt-load of the river during the period of sedimentation.

†The term "pindan" is used in the West Kimberleys to cover a variety of soils commonly sandy in nature, but sometimes gravelly, which occur at some distances from the rivers where surface waters do not occur.

This soil has been named the "Cununurra clay," after the native name for the Ord River.

The clay soils associated with the basalt plains carry a similar vegetation and look rather similar on the surface, except for a pavement of basalt stones and boulders. Fragmentary and decomposing basalt occurs at shallow depths.

(b) Shallow soils of the upper Cambrian flaggy limestones and mudstones of the upper Ord basin.—Associated with the mudstones of the upper Ord basin are plum-coloured loams and clays, and grey-brown, powdery soils have formed on the flaggy limestones. The country is gently undulating with low breakaways where the edges of the slightly dipping limestones have been exposed by geological erosion.

Fig. 4.
Bauhinia and grass on Cununurra clay.
Photo, W. H. Maze.

In the virgin state these plains carried a short grass cover with a sprinkling of small trees. Unfortunately the grass has suffered severely from grazing and, with the cover reduced, these soils have proved most liable to soil erosion. It is estimated that about 2,500 square miles of grassland country of this type in the upper Ord basin, including the Negri River in the Northern Territory, has been more or less affected. Half of this area is in a serious condition. The story of soil erosion in the Ord River basin has been carefully studied by Mr. F. G. Medcalf for the Department of Lands and Surveys. It is hoped that his report may be published in due course.

(c) Areas liable to periodic flooding.—An interesting vegetation association on the flood plains is the gutta percha (*Excaecaria parvifolia*) and coolibah (*Eucalyptus microtheca*) on areas liable to flood. The soil seems similar in nature to the dark grey heavy soils of the grasslands and savannahs, except for some modification resulting from the extra moisture. The provision of drainage would be necessary before these soils could be utilised intensively.

3. The woodlands of the river courses: The rivers and small streams are characterised by a fringe of grassy woodland in which a variety of trees have established and often form a very attractive association. Important among these trees are the chestnuts (*Terminalia* spp.), the Leichardt tree (*Sarcocephalus* sp.), the wood of which is a very attractive yellow colour and may be made into attractive furniture, various figs (*Ficus* spp.), cajuput (*Melaleuca leucadendron*), native apple (*Owenia* spp.), baobab (*Adansonia Gregorii*), various eucalypts, including grey box (*Eucalyptus Spenceriana*), river gum (*E. camaldulensis*), bloodwood (*E. pyrophora*) and cabbage gum (*E. clavigera*). See fig. 5.

(a) The soils of the river fringes are forming on recent alluvium and are amongst the most attractive of the areas. Generally, they are not extensive in area and in many cases have been severely damaged by soil erosion of both gullying and sheet types. The colour is usually brown but is sometimes grey on the surface. Textures range from sandy loam to light clay and the profile is usually deep and permeable. The Experiment Farm at Carlton Reach was located on alluvial soils along the river fringe. Results show them to be very productive with respect to a range of crops under irrigation.

(b) Between the brown alluvial soils along the river and the dark grey or dark grey-brown clays of the grasslands is a group of brown soils of heavier texture than the alluvials, but carrying a similar grassy woodland.

4. In the northern part of the Kimberleys where the rivers have cut deep gorges there are small areas of dense tropical forests growing in the bottoms on continually moist soils. They have been described as corridor forests. These have not been examined, but are of limited importance in view of the inaccessibility and the small area.

5. Where the moisture conditions are more favourable, largely due to seepage areas, an interesting variety of plants, including Pandanus palms, ferns, etc., established on sandy soils. Associated with these areas is the interesting poplar gum.

The response of many of the trees of the area to the seasons is most marked. Most of the trees, even eucalypts, are deciduous. They drop their leaves in the winter and the buds burst again after a few weeks in what amounts to a spring. Particularly interesting in this connection is the *Bauhinia*, which drops its leaves in July, flowers in August, and develops its new leaves in September.

One of the most spectacular trees of the area is the baobab or bottle tree. Trunks up to 20ft. in thickness may be observed. These look exceptionally bulgy below the umbrella shaped top branches. This tree is deciduous and looks very bare in August and September after the leaves have fallen. At this time the large globular fruits are very apparent. The centre of the trunk of the baobab tree consists of a fibrous material, highly carbonaceous in character, and which is reported to have been used successfully for drought feeding of stock.

Soil salinity appears to be of very minor importance in the area, except in the tidal flats near the mouths of the streams. On account of the high tides of the area, up to 30ft., large areas of mud flats near the mouths of the rivers are liable to flooding by salt water periodically. On the Ord, the influence of the salt extends for about 30 miles upstream and in consequence some of the flood plain soils are regarded with suspicion on account of a considerable concentration of salt in the lower layers. These soils show little pedogenic development, being relatively recent mud deposits. Experimentation would be necessary to decide whether these could be developed for grass establishment under irrigation. Experience in Kerang, Victoria, indicates that there is some prospect for success where careful flooding can be practised to prevent the rise of salt from the subsoil.

H. LAND UTILISATION, PAST, PRESENT AND PROSPECTIVE.

1. *Past.*—The early pastoralists introduced a simple method of stock husbandry. Leases of up to 1 million acres were obtained and the cattle allowed to graze practically at will over the grasslands. In any case, no fences were used, except in the immediate vicinity of the homestead. In consequence, cattle overgrazed parts which were suitably placed with respect to water, and where the feed was palatable. Other areas were neglected.

After 60 years the carrying capacity of many parts has been seriously reduced, and the quality of much of the stock is far from satisfactory; parts of the country have suffered severely from soil erosion due to the destruction of the native vegetation cover. It is reported that areas in the upper Ord basin, now almost completely bare of grasses and on which the trees are now dead, carried a rich sward of short grasses of high palatability and provided the forage for a large population of cattle as recently as 20 years ago. In spite of the damage suffered, the total number of stock in the Kimberleys has not been greatly reduced to the present. But the insidious development of erosion shows that management must be modified in the future to effect conservation of the natural resources and, at the same time, improve the stock carrying capacity.

2. *Present.*—At the present time many of the pastoralists are considering improvements in their methods of management. Bullock paddocks, usually of about 100 square miles, have been fenced and introduction of sires has been practised in an attempt to improve the strain. By improved management on a number of stations, a better class of stock has been produced in recent years, but the quality in most cases is still well below the requirements for a prime beef industry.

The introduction of sheep, particularly at Noonkanbah and Liveringa, points to the utilisation of other stock as a practical possibility.

3. *Prospective.*—Mr. Connellan, president of the Northern Territory Development League, and one of the pioneers in air transport in the North, has given a considerable amount of thought to the future development in the area. He is anxious that thorough investigation be organised so that any future development in the district will be on sound lines and has made certain suggestions which are worthy of careful consideration:—

i. Mr. Connellan believes that the pastoral activities will be the basis of development in the near future. He suggests that large holdings should be encouraged on account of the patchy distribution of much of the rainfall. If the country were cut up into small areas it is conceivable that some holdings may miss the rainfall entirely and the stock suffer from drought owing to the inability of small owners to shift to other more favoured areas.

ii. Associated with the large holdings should be small, say 200 acres, irrigation farms for the production of irrigated pasture and fodder crops in order to provide feed during the latter part of the dry season when cattle lose condition very rapidly and obviously suffer from nutritional troubles of which protein, vitamin A and other deficiencies are suspected of being important.

iii. The development of water, rail, road and air transport.

iv. The introduction of engineering works to control floods and make provision for irrigation water and power to serve the area. An important aspect of this work will be the control of erosion in the catchment areas which should be liable to lead to the siltation of dams.

v. The introduction of crops. At the outset, it must be realised that the present species established under natural conditions are of little or no value in the improvement, under irrigation, of the pastoral and agricultural activities of the district. They are incapable of responding adequately to improved moisture and soil fertility conditions and it is necessary, therefore, to search for suitable crops if intensification of the area is attempted.

It is of interest that a number of trials have been made in the past, unfortunately with little success. Cotton has been attempted at Derby and Wyndham.

However, station gardens from about April to December prove highly productive of vegetables and fruit under irrigation. A number of physiological and parasitic troubles, including white ants, are among the disabilities suffered. In spite of this, production is high and these gardens are regarded as eminently successful.

Fig. 5.
Mantinea Flats with House Roof Hill in the background
Prof. S. M. Wadham photo.

In spite of the many enthusiastic reports, it is evident that much research will be necessary to devise improved methods of range management and to establish the suitability of irrigation crops for the Kimberley conditions and methods for their management.

(a) *Range Management.*

It is obvious that the early methods of unrestricted grazing on the natural waters is unsatisfactory and promotes deterioration of stock and country. It seems that the first steps in improved management should involve a great deal of fencing and provision of adequate water supply to allow proper handling of the different types of stock in the herd, and the introduction of new blood.

(b) *Pastures.*

For irrigation country, pastures which will grow practically continuously under the modified climatic conditions prevailing are required. For the Kimberley latitudes, grasses of the wet monsoonal areas offer most promise. Para-grass (*Brachiaria*), Paspalum and Rhodes grass (*Chloris Gayana*) are the most promising of the grasses tested at the Ord River. Lucerne, which is most successful under more temperate conditions, has shown the greatest promise of legumes under the test when grown with grasses such as Paspalum.

Stylosanthes, a tropical legume receiving some publicity from Queensland, has proved disappointing up to date. Other pasture species, common under tropical conditions, exhibit a marked period of dormancy during the year and of these birdwood (*Cenchrus setigerus*) and buffel grasses (*Cenchrus ciliaris* and *C. pennisetiformis*) are aggressive but comparative weeds in irrigated pasture.

(c) *Crops.*

Sown crops which offer possibilities are rice, cotton and grain sorghum. Unfortunately the cotton boll weevil occurs in the area, the host being a native cotton. The question may be asked whether Grey inadvertently introduced this pest in 1837 when he established his garden at Hanover Bay.

(d) *Horticultural Crops.*

Horticultural crops of a wider range suggest themselves. Papaws, bananas, citrus and dates and a host of other tropical fruits and nuts could be investigated.

(e) *Vegetable Crops.*

In the cooler period of the year most temperate vegetable crops do exceptionally well. Tomatoes, pumpkins, sweet potatoes, melons, cabbages, peas and beans are prominent in all station gardens and have done well on Carlton Reach plots. There are suggestions of a number of problems associated with vegetable growing in the area, possibly physiological owing to the climatic and, perhaps, soil conditions. For instance, tomatoes planted in the wet period do not set their fruit until about June. Planted about April, they come into bearing normally and produce heavily until about September, after which time the fruit becomes smaller and the plants less vigorous.

1.—THE PLACE OF THE SCIENTIST IN THE KIMBERLEY PROJECT.

There is no doubt that any future development of the Kimberley area, involving the introduction of a programme of intense agriculture and revision of pastoral methods, will require the fullest use of all phases of science if maximum success is to be attained.

In fact, past experience suggests that the project would be a costly failure without the fullest application of the scientific method. As Mr. Connellan points out, it is better to spend a few years in intensive and co-ordinated research than to rush into an ill-considered scheme. At the outset, in the research stage the question of cost should not enter, but the endeavours should be directed to the working out of methods which would be necessary for the establishment of a sound developmental programme. Having discovered these methods, the economics can be worked out and the basis provided for the political leaders to decide on a national policy. It may be necessary for the nation to develop the area irrespective of the economics of production. However, until the possibilities for production are known these aspects can be nothing more than mere guesses and may result in unwise decisions.

There is no doubt that the Kimberley project constitutes a challenge to the scientist. Several lines of attack suggest themselves, based on the experience we have had to date:—

1. A scientific survey of the natural resources, including soils, minerals, hydrology and natural pastures. The obvious method of attack involves the use

of aerial surveys to the utmost as a foundation for ground work with respect to soils, engineering, transport, etc. This survey will involve the collaboration of the soil surveyor, the land surveyor, engineer, ecologist and geologist.

2. The study of existing plants and animals. The value of existing grasses for stock purposes is fairly well understood and their limitations appear most important in the present stage of development. There are many other species, however, which are of importance in other respects. First of all there are drug plants, such as Barringtonia, a fresh-water mangrove used by natives as a fish poison and which probably contains rotenone; the quinine tree (*Petalostigma sericea*), which contains a bitter principle of unknown physiological importance; and the strychnine bush (*Strychnos lucida*), which may represent a local source of this poison. Other plants and animals may be important as pests, disease vectors, etc. Certain local plants, such as the gogo bush (*Corchorus vermicularis*), may be valuable in the renovation of areas damaged by soil erosion.

3. Plant and animal problems suggest themselves. The chemist in particular will be required to provide information regarding the composition of fodders and other products. The question of animal nutrition will need thorough investigation.

4. Soils and irrigation problems. With the adoption of irrigation as a means of introducing intensive agricultural methods a number of important scientific problems will have to be faced. It will be necessary to have information regarding the composition of waters, the stability of catchments and the liability of the eroded areas to damage the reservoir. The behaviour of the rivers and their tributaries will require especial attention from the engineers. To ensure permanent and successful irrigation the soils of the area need thorough examination both in the field and in the laboratory.

Important aspects not at present receiving attention in this State, but which must be recognised and attacked, are soil physics and soil physiology. The question of the stability of the soils under irrigation and the cropping programme, the liability to water logging and such like problems in soil physics need immediate attention in order that a sound judgment of the soils may be made. The importance of the biological factors in the soil, the activity of the myriads of bacteria, fungi, actinomycetes and, in the Kimberley areas, insects such as white ants, is realised but imperfectly understood. These factors may contribute substantially to the success and also to the difficulties in developing an intensive agriculture.

The scientific problems of the Kimberley project appeal as an interesting and stimulating challenge. Many of them appear to present little in the way of formidable obstacles and most of them should be resolved when the appropriate scientific information has been collected.

I was impressed by Professor Wadham's suggestion that a research station be established on the Ord and £25,000 a year spent on scientific investigations prior to a decision regarding the project. This indicates the line of attack which should be organised as early as possible, certainly some years before the first settler is placed on his block, if it is decided to proceed with development.

Of greatest difficulty are the political, social and economic problems. Of these I have nothing to say, except that I believe that the Australian, given appropriate encouragement, will be the best man to develop the resources of the State whether in the Kimberleys or elsewhere. I am glad that Captain Stirling's proposal that the development of Western Australia is dependent upon the introduction of abundant labour and low wages has not been accepted. There is every evidence that labour under such conditions is neither efficient nor satisfactory.

Tomato Culture in the Geraldton District.

N. Davenport, Agricultural Adviser.

INTRODUCTION.

From a very modest beginning about twenty-five years ago the tomato growing industry is now an important phase of the agriculture of the Geraldton district. Its continued expansion has been checked by the present war conditions during which production has decreased, due principally to a shortage of manpower. No doubt this decrease is a temporary one and under peace-time conditions there is every reasonable expectation that further expansion of the industry will take place.

Wartime nutrition research has emphasised the dietetic value of tomatoes and it is expected therefore, that the demand for them will increase appreciably. In meeting any such general demand the Geraldton district is fortunate in that the time at which its fruit is ready for market, viz., June-November inclusive, coincides with a period of short supply both in the Eastern States and in the metropolitan area and other districts south of Geraldton.

The following table shows the annual production of tomatoes for the ten years 1934-43 inclusive:—

Year.	Area. Acres.	Yield Tons.	Year.	Area. Acres.	Yield Tons.
1943 ..	386	3,035	1938 ..	378.5	3,252
1942 ..	254	1,432	1937 ..	345.75	2,488
1941 ..	371	3,977	1936 ..	300.5	1,778
1940 ..	414.5	3,657	1935 ..	304.5	2,153
1939 ..	472	3,768	1934 ..	339	1,382

SUITABILITY OF THE DISTRICT.

The tomato plant is very susceptible to damage by frost and hence commercial planting is at present restricted to within approximately ten miles of the coast, except for known frost free areas further inland. The majority of the gardens are situated within a radius of six miles of Geraldton.

The incidence of the harmful frosts is not on record, but it is very low. Only one serious general frost has been experienced in fourteen years. Other minor frosts have occurred which have killed flowers and interfered with fruit setting on a portion of the plants.

Being adjacent to the coast the climate is an equable one and is of the winter rainfall type. The rainy season extends from late April to September inclusive, with the remaining period of the year comprising the well recognised summer drought period of the South-West of this State.

The average monthly registrations of rain for a period of 64 years is as follows, together with the absolute maximum and minimum range*:—

Period.	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Average, 64 years	22	29	57	92	272	477	379	279	128	70	26	15	1,846
Range	0 to	0 to	0 to	0 to	24 to	132 to	70 to	33 to	4 to	0 to	0 to	0 to	
	379	459	666	365	1,292	1,292	808	952	412	275	157	126	....

The average maximum and minimum monthly temperatures for the past 44 years are shown below:—

Month.	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Average Maximum	84·5	85·3	83·7	80·2	74·0	69·6	67·8	68·9	71·2	73·4	77·8	81·6	76·5
Average Minimum	65·7	66·3	64·3	60·5	56·5	53·4	51·2	51·7	52·8	55·2	59·2	62·9	58·3

*Meteorological data kindly supplied by Commonwealth Meteorological Bureau, Perth.

SOILS.

The soils vary from deep fertile red brown sandy loams and sands to the common deep grey sands often overlaying yellow sands, typical of the coastal belt of South-Western Australia. They are well drained and well suited to vegetable production generally.

VARIETIES.

The principal variety originally grown was a selection from an unidentified variety which yielded a heavy crop of large fruit of the crinkly or Chinese type. It became known as the "Geraldton Crinkly."

As this type lost its favour with consumers and the demand grew for smaller smooth round fruit, so the production of this crinkly variety gave way to what has become known as the "Geraldton smooth skin," which is an early maturing variety of high yielding capacity. It holds its flowers well. The fruit is fairly small to medium in size, smooth, round and slightly flat. It was selected from a proved type which was itself unidentified. Other smooth skin varieties, e.g., "Sensation," are grown to a smaller extent.

The demand for the smooth skin type is so great that the crinkly type is now grown only as a late crop for the metropolitan market.

SEED SELECTION AND TREATMENT.

It is the general practice for each grower to raise his own seed. Well grown typical plants are selected, which have had no obvious growth advantages, have produced a high yield of good fruit and show no abnormality of growth or evidence of disease (except of course "black spot" (*macrosporium solani*)). The fully ripe fruit from these selected plants are cut open and the soft pulp containing the seeds is squeezed into a container. No water is added. This pulp is allowed to ferment for 3-5 days until the seeds are free from pulp. An equal part of water is then added, the whole vigorously shaken or stirred and after allowing the seed to settle, the overlying liquid is poured off. Water is again added and the process repeated until only clean seed is left. At this stage, just prior to drying, the seed is ready for disinfection against seed-borne disease-producing bacteria or fungi, such as fusarium wilt. This is done by soaking it for five minutes in a solution of corrosive sublimate 1 : 3,000, i.e., 1 tablet to 3 pints of water, pouring off the solution and washing thoroughly several times with clean water. This seed is then spread out thinly on fine screens or smooth cloth to dry as quickly as possible.

The writer used the acid method for seed extraction as recently recommended by the C.S.I.R. Good extraction was obtained in one hour using commercial hydrochloric acid at the strength of 4 ozs. to 25 lb. of pulp.

PREPARATION OF SEED BEDS.

The climate permits of all seed beds being in the open and renders the raising under glass unnecessary. There are three separate plantings for the early, mid-season, and late crops respectively, although many growers plant a main crop only. The sets of seed beds for each crop are kept separate and it is now recognised that each set should be placed as far apart as possible on the property, in order to reduce the likelihood of thrips carrying the virus of spotted wilt from the earlier to later plantings.

Among the better growers it is now considered advisable to sterilise the seed beds with either formalin or heat by means of burning wood. A site apparently free from disease and eel worm is chosen and a formalin solution made by diluting

one part of commercial 40 per cent. formalin with 49 parts of water is applied by watering can or other suitable means at the rate of half a gallon per square foot. The bed is then covered with bags and left for a week after which it is well dug and left to aerate for several days.

A dressing of tomato manure or a mixture of blood and bone and tomato manure varying from ¼ lb. to ½ lb. per square yard is lightly dug in. After levelling and raking, the seed is planted in rows 4-5 inches apart or broadcast, and then covered with soil to a depth of about ¼ inch. Stable manure is usually lightly sprinkled on to form a mulch.

Fig. 1.
Showing seed bed in paddock already staked.

CARE OF SEEDLINGS.

The beds are watered once or twice daily according to the weather and after germination usually once daily. After a week above ground the seedlings are dusted to check fungus diseases and insect pests. A recognised effective mixture for this purpose comprises 25 per cent. copper carbonate, 30 per cent. lead arsenate, 25 per cent. sulphur and 20 per cent. lime as filler. The dusting is done in the evening and washed off next morning with the watering to prevent damage to the tender growth by the sun's rays. Dusting the plants is considered more satisfactory than spraying at this stage of their growth and is done at weekly intervals unless special circumstances require it more often.

The seedlings are thinned out, as soon as practicable, to about an inch apart in order to produce healthy strong broad-shanked plants. They are ready for planting out in four to five weeks.

ROTATION.

The rotation most generally practised is one of four years, viz., tomatoes, peas or beans, cereal and fallow.

Peas or beans are planted on the reploughed area following a crop of tomatoes in order to take advantage of the residual effect of the heavy dressing of fertiliser the previous year and also because the soil is already in good condition and is also likely to carry less weed growth. The cost of the crop is small, the peas being drilled in and interrow cultivation given by horse drawn machine. Intrarow cultivation is often omitted.

The cereal crop, either wheat or oats, is planted on fallow which has been ploughed immediately following upon the completion of pea picking or on the land which is not ploughed until just prior to planting. Providing this crop is reasonably free of weeds, it serves as a control for eel worm which does not parasite cereals. It also provides fodder for the horses used on the garden.

Towards the end of the following winter the ground is again ploughed, as deeply as possible, burying any weed growth upon it. Except in one or two cases, the growing of a special renovating crop such as lupins or tick beans or other legume is not practised.

PREPARATION OF PADDOCKS.

The individual paddocks vary from ¼ to one acre in area and are usually approximately one chain wide. In order to check the effects of wind, they are bounded by light brush fence 5-7 feet high and run in a north-south direction.

It is the general practice to plant on fallow which has been ploughed during the previous winter. The initial working is done to as great a depth as possible and varies from 8-12 inches or even more. No working is then given unless summer rains occur when it is reploughed or cultivated. Prior to planting it is again ploughed deeply and is then ready for planting out. It is becoming the practice to apply a dressing of fertiliser during this final ploughing burying it as deeply as possible by placing it along each furrow as it is opened up or by broadcasting just prior to ploughing. Quantities varying from 5-7 cwt. per acre are applied, either of tomato manure or a mixture of blood and bone and potato manure. This is done with the object of enticing the roots to lower levels and so lessening the effect of dry spells during the growing period.

PLANTING OUT.

The plants are planted out in double rows which vary from 2ft. to 3ft. 6in. apart. Between each double row is a width of 3ft. 6in. up to 4ft. to allow of inter row cultivation with horse or power drawn implement. The plants are spaced from 2ft. to 2ft. 6in. in the rows. After thoroughly watering the seed bed, the best and strongest plants are gently pulled out and placed in baskets or other suitable containers, handling them as little as possible. The planter uses a small planting hoe and after making a small hole with one strike of the implement places the plant in position, somewhat deeper than when in the seed bed, and presses the soil back with the hoe blade. The plant is then watered in with about half to a pint of water. Care should be taken that as little time as possible elapses between plucking from the seed bed and replanting.

An average planting is six thousand plants to the acre.

STAKING.

When tomatoes were first grown in this district the practice was to produce a "ground crop," i.e., to allow the plants to lie on the ground unpruned, without any support whatever. Much fruit was lost through damage as disease became more prevalent, "Black Spot" losses particularly became so heavy that it was

found imperative to raise the plants from the ground. This was first done by tying them to wires drawn taut to posts at each end of the rows, but this practice has been superseded by that of tying each plant to a separate stake.

While the practice of vertical staking is gaining ground, the usual method is to lean the stakes of each double row inwards and fasten by hitching with a continuous tie wire to a central wire, about four feet from the ground, stretched from stout supports at each end of the rows. It is usual also to stagger the planting so that any plant in one row is opposite the centre of the space between plants in the other row. This facilitates the later operations of dusting, spraying, picking and pruning and also allows of better air circulation and more sunlight to each plant.

Stakes vary from 5-6 feet high out of the ground.

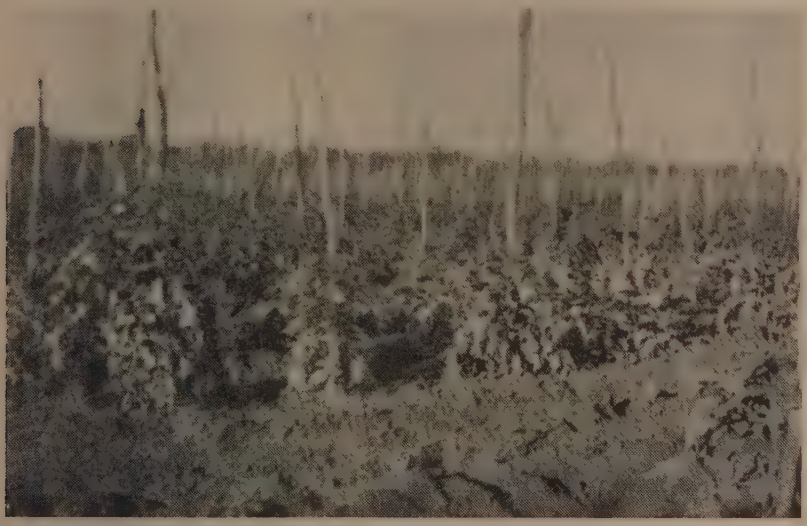


Fig. 2.
Showing vertical stakes.

CARE OF THE GROWING PLANTS.

(a) *Fertilising.*

The standard fertiliser is tomato manure with an analysis of total phosphoric acid 11.5 per cent., nitrogen 3.5 per cent., and potash 8 per cent. In normal times dressings totalled 15 cwt. to 20 cwt. per acre, but under wartime restrictions, permits are issued for a maximum of 15 cwt. per acre, only. This is usually given in three equal separate applications. The first 3-4 weeks after planting out and the remainder at 3-4 week intervals. Where fertiliser has been ploughed in prior to planting, the balance only is available. The first application is given by sprinkling by hand in a circle round each plant and about 6in. out from it. The second is given the same way but with a greater distance from the plant. The third is commonly applied by dibbling in shallow rows which have been opened up adjacent to the plants and then turning back the soil to cover the fertiliser.

Towards the end of the season, when the fruit tends to become small, a dressing of nitrate of soda at about ½ cwt. per acre, is sometimes given, dissolved in irrigation water and with very good results.

(b) *Weed Control.*

Inter-row cultivation is given periodically with either horse or power pulled light cultivator. Besides killing weeds, this aerates and loosens the top soil which becomes consolidated by the traffic of the workers.

The weeds in the remainder of the area, as it is not possible to cultivate in a similar manner because of the stakes, are controlled by repeated hand hoeing.

(c) *Pruning and Tying.*

The plants are pruned to one or two leaders according to the fertility of the soil and distance between plants in the rows. It is becoming the practice to allow strong growth to be made before the first pruning in order to produce robust root development in the early stages. If training to two leaders the lateral immediately below the first flower cluster is left to form the second leader. Subsequent to the first pruning all laterals are pinched out at regular intervals as the work of the garden permits, the main laterals being those immediately under the flower stalks and colloquially termed "Sap shoots."

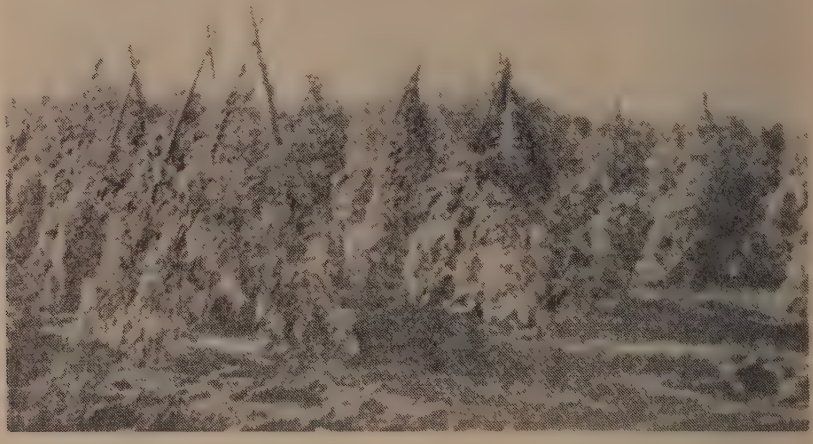


Fig 3.
Showing plants tied to leaning stakes.

Pruning is done by hand, breaking off the lateral close to the base with a quick action of the fingers.

As the plants increase in height so does the risk of damage by wind. To prevent this, the leaders are tied firmly to the stakes. Unravelled old rope is usually used for this purpose, care being taken that the strands are not thin enough to bite into the leader and that the tying is done sufficiently tightly to prevent wind action causing undue rubbing which results in damaged leaders and fruit. Three or four tyings are usually sufficient during the season.

DISEASE AND INSECT PEST CONTROL.

This is a very important factor in the success of tomato culture in this district. The following information and recommendations have largely been com-

piled from the Department of Agriculture leaflets, a list of which is appended below. These are available on application and give fuller details regarding the different pests and diseases mentioned.

Climatic conditions during late autumn, winter and spring are favourable to the growth of cutworms, aphis, thrips, rust mite, eelworm, mole crickets and other pests of minor importance. Conditions during July and August are usually particularly favourable to the growth of fungus diseases such as black spot and fusarium wilt.

INSECTS AND OTHER PESTS.

(a) *Below Ground Level.*

Eel worm occurs in patches on many of the gardens and it is to be expected that in the not far distant future, its control will be a major problem. No direct

Fig. 4.—Showing young plants of early planting, and irrigation channel.

method of control is at present being practised, partly due to the price and difficulty of purchasing effective agents.

Mole Crickets, known locally as "farmers," may cause considerable damage early in the season when they attack the stems of young plants just below ground level, usually completely severing them. For control a good method is to follow the plough just prior to planting (*i.e.,* for the main winter crop) and gather these insects as they are exposed. An instance is known when 1,200 were so gathered in an area carrying 30,000 plants. The great potential danger of such a number is obvious when it is known that one insect may destroy quite a number of plants.

Another successful control method is to place small poison baits (made up according to the following formula, bran 25 lbs., Paris green or arsenite of soda 1 lb., and water just enough to make into small lumps) just under the surface and adjacent to the plant but not touching it. Again the stems up to two inches below the surface may be wrapped with sacking or small preserve tins, with the bottoms removed, may be pressed into the soil round each plant.

(b) *Above Ground Level.*

Cutworms.—These are the larvae of several species of moth including the tomato moth, which are present in the gardens throughout the growing period

but are most troublesome during the early winter and spring periods. They spend the larval stage on the plant, principally on the underside of the leaves. They are readily controlled.

During the period when spraying is carried out the addition of 2 lbs. of arsenate of lead to 40 gallons of spray is very effective except that where the larvae attack the fruit, and have burrowed inside, such a poison spray is unable to reach them and is, therefore, ineffective. The proportion of fruit so lost is low.

When dusting is used for insect control the addition of lead arsenate to the dust is effective.

Aphis.—These insects are also present during the whole growing period. The addition of half a pint of Black Leaf 40 to 40 gallons of spray gives good control although if the adults are allowed to fully mature they are then more difficult to kill.

The addition of 5 to 8% of tobacco dust to the dusting mixture when spraying is not carried out, is also effective.

Thrips.—These are also present during the growing season but are specially troublesome at the commencement of the season. There is ample evidence to show that outbreaks of spotted wilt originate in the seed beds principally and the disease is taken to the paddocks by the seedlings. Little success in controlling spotted wilt has resulted from the use of Black Leaf 40 on plants in the seed bed and although it is to some degree effective, the control is by no means sufficient. There appears to be little spreading of spotted wilt on to healthy plants in the paddocks. The latest sprays such as tartar emetic spray and others recently recommended by various workers have not yet been properly tried out in the Geraldton area.

Rust Mite occurs chiefly in the spring period but is also present during the autumn and to a slight extent in the winter months. Dusting with sulphur is quite an effective control as is also spraying with lime sulphur at a dilution of 1 : 80, a stronger solution is liable to burn the foliage on a hot day. The formulae for dust for insect pest control vary considerably among the growers, while some use arsenate of lead 25 per cent., sulphur 50 per cent., tobacco dust 5 per cent. and filler 20 per cent., and which is quite effective, others use sulphur 50 per cent. and arsenate of lead 50 per cent. with no filler but a lighter application.

Disease Control.

The three principal diseases with which growers have to contend are, first and foremost, Black Spot or Early Blight (*Macrosporium solani*) and Fusarium Wilt (*Fusarium lycopersici*) and spotted or Bronzy Wilt, in that order.

Other diseases such as "Damping off" of seedlings, bacterial wilt, and the virus disease, mosaic and bunchy top are all of low incidence and generally of little economic importance.

Black Spot or Early Blight.—Conditions of moisture and temperature are most suitable for the rapid growth of this fungus during the period of late June to early August. The disease is most commonly found on the leaves and it is recognised by the presence of circular or irregular dead areas which are dark brown to almost black. The spots usually develop first on the lower leaves where resistance is lowered due to age. These affected areas increase in size and new healthy tissue is invaded according to prevailing weather. If uncontrolled the whole plant is soon affected and dies off from the bottom leaves upwards. It is readily controlled by spraying the Bordeaux mixture 4 : 4 : 40. Spraying commences about the middle of June and continues generally to the latter half of August. It is done at intervals of approximately a fortnight or more often if weather conditions require it. As described earlier, lead arsenate and black leaf 40 are added to the Bordeaux mixture to control insect pests.

The black spot fungus attacks the fruit as well as the leaves and stems and considerable loss sometimes occurs through infection of the fruit from the calyx. So far attempts to control late infection of this type have not been successful.

Fusarium Wilt occurs generally throughout the gardens of the Geraldton district. It is a soil borne fungus and persists for many years on affected areas. The disease causes wilting and may be recognised by the yellowing and dying of the leaves from the bottom upwards. One leader may be affected and the other apparently quite healthy for a considerably longer time on the same plant. If cut open longth-wise or pulled open at a fork in the stem, a dark discoloration will be found in the sap conducting tissues of the affected branches.

No control is possible by treating infected plants as infection gains entrance through the roots. The only means of control are to ensure that the seed is disinfected with corrosive sublimate as described earlier and so kill any spores of the fungus which may be attached to the seed coat; that a suitable rotation is practised and that the disease is not further introduced on to a property by seedlings, implements, or animals which have been fed on affected tomato plant top.

Seed bed disinfection with formalin or heat is obviously essential. Unfortunately the local variety of smooth skin is susceptible.

Spotted Wilt.—This virus disease occurs to a serious extent only in odd seasons although it is always present in the gardens to a slight extent. Unfortunately little is known as yet of the reason for these sporadic outbreaks. It has been the experience of gardeners of recent years that if the disease can be kept out of the seed beds there is every chance of escaping a general infestation in the paddocks. It is noticeable that no spotted wilt has yet occurred in that part of the Utakarra area which is practically devoid of natural vegetation.

Unfortunately the methods used to contact thrips have, as elsewhere, proved unsatisfactory, although the thrip population can be kept in check somewhat with either Black Leaf 40 or white oil. This virus has an exceedingly wide host range which greatly increases the difficulty of control. The main hosts responsible for the oversummering of the virus have not yet been determined for the Geraldton area and they may include the native flora.

Garden Hygiene.—The present practices in garden hygiene are inadequate for reasonable control of disease. When the industry was first established in Geraldton disease incidence was particularly low and therefore despite departmental advice no special precautions were taken by growers. This has inevitably increased the prevalence of disease so that now concerted action by growers is imperative if the position is to be appreciably improved.

The practice of obtaining seedlings which cannot be guaranteed free from disease is a fruitful source of spreading fusarium wilt and spotted wilt among the gardens.

It is obvious that stakes may readily spread soil borne disease if not disinfected. No stakes, once used, should be used again unless they have been made free of infection. This can be done by dipping one end up to 18 in. deep in a bath of formalin made by diluting one gallon with 40 gallons of water or in a bath of bluestone (10 lb. to 50 gallons of water).

Plants infected with fusarium wilt and other soil borne fungi should as soon as recognised be pulled up, bagged and burnt. When plants are permitted to dry off completely in the paddock, portions of the plant infested with the spores become detached, and so spread the disease over clean areas. On no account should stock be permitted to feed off tomato tops affected with this disease, as this is obviously a common reason for its spread.

Plants affected with spotted wilt should be either carefully bagged or buried in a hole made just adjacent to them. If this is done carefully many of the thrips on the plant may be buried and so at least reduce the number of infective insects, besides lessening the chance of thrips becoming infective by feeding on such plants.

Care should be taken during pruning and other operations that diseased plants are not handled at the same time as healthy plants. Bacterial wilt and other diseases can readily be transmitted to healthy plants in this way, but this is not the case with spotted wilt.

Immediately picking has finished for the season, all plants should be pulled up (not cut off at the base), and burnt as soon as dry. As little refuse as possible should remain unburnt. Any material not destroyed is a potential infective agent for the next crop. It is a very unsound practice to leave the remains of a season's growth lying on the ground until next autumn as is so commonly done at present. The usual object of leaving such material is to check wind erosion, but the benefit so gained is a very expensive one and the practice is to be condemned.

It is obvious that the sooner cleaned up paddocks are ploughed over to bury that refuse which it is impossible to burn, the greater will be the improvement in disease control. A period of three years should elapse before land is again cropped to tomatoes, except perhaps in the case of newly cleared gardens.

A cereal crop followed by a fallow year previous to planting tomatoes is of considerable benefit in controlling soil-borne diseases and insect pests and is strongly recommended.

The choice of a suitable renovating crop to be ploughed in at fallowing time is dependent upon the question of the susceptibility to disease of the crop chosen. No special attention has yet been given to the choice of such a crop and at present weed growth is used for renovation. There is much to be done in this connection.

CONCLUSION.

The practice of tomato culture as outlined has been developed in the main by trial and error. As the industry is now well established and of considerable economic importance, there is obviously scope for experimentation to obtain further information on such of its phases as soil preparation, crop rotation, fertiliser mixtures and methods of application, dusting mixtures and also varietal improvement by selection and the testing of introduced varieties.

ACKNOWLEDGMENT.

Acknowledgment is made to those growers who have so readily supplied information and thanks are in particular due to Mr. G. K. Allen, an outstandingly successful grower for his advice and co-operation always so generously given.

The undermentioned leaflets dealing with various phases of this subject are available free on application to the Department of Agriculture, Perth:—

Spotted Wilt of Tomatoes.
Fusarium Wilt of Tomatoes.
Bacterial Wilt of Tomatoes.
Blossom-end Rot of Tomatoes.
Vegetable Seed Treatments.
Seed and Seed-bed Disinfection.
Tomato Rust Mite.
The Red Spider.
The Climbing Cutworm.
Mole Crickets.
Aphis Control.
Green Tomato Bug.
Thrips and Their Relation to Spotted Wilt and Other Plant Injury.

Sampling of Milk for Chemical and Bacterial Analysis.

K. NEEDHAM, Agricultural Adviser.

The importance of the correct procedure of sampling of milk for bacterial and chemical analyses is discussed: a description of the apparatus used is given and the methods and apparatus employed by inspectors of various controlling bodies is described, together with recommendations for methods of taking reasonably accurate samples by producers or home consumers.

INTRODUCTION.

Many persons are of the opinion that analysis of milk or any other material is confined simply to the performance of a specific test and the reporting of the result obtained. Actually the test itself is only portion of the work as it is of equal importance that the results be interpreted correctly. Accordingly any results obtained are of little significance to the person performing the test unless certain other information is known. This information, including the past history of the material, will alter the picture obtained very materially. It embraces the conditions under which the material was sampled, the conditions under which it was held after sampling and before delivery to the laboratory and numerous other specific facts associated with different tests.

One of the most important factors in any analysis is the method of sampling. If the person performing the test knows that the sample has been taken efficiently, and is informed of the method of sampling, then he is in a position to report on the results of his finding with confidence.

It is proposed in this article to discuss the importance and various methods of sampling of milk both for chemical and bacterial analysis. Before enumerating these techniques a word of advice will be helpful to all persons submitting samples.

Type of Samples Submitted.

Two main types of samples are received at the dairy laboratory, those taken by officers of the Agricultural Department, and inspectors of the Metropolitan Milk Board, and those submitted direct by producers or consumers themselves. In the former case when a sample is forwarded to the laboratory a request is made, unless in exceptional circumstances, for a specific test or tests. Very frequently, however, in the case of samples submitted by producers or consumers, a covering letter is received in the following strain:—

> "I am fowarding under separate cover a sample of milk which is unsatisfactory. Will you please test it."

The number of both chemical and bacterial tests which can be performed on milk is very considerable, and no laboratory staff has the time nor is the supply of reagents sufficiently abundant, to perform all of these analyses needlessly on one sample. Furthermore, if it did, many of the tests performed would be of little or no interest to the person concerned. If it is considered that the milk is low in butterfat content or total solids then a request for an examination along these lines should be submitted. If, on the other hand, it is felt that the milk is unclean bacterially, or that it contains preservatives, here again these suspicions should be nominated. Any fault or condition at all which prompts a person to submit a sample, should be mentioned at the time of the submission in order to assist in deciding just what analyses should be performed.

Condition of Sample.

Milk for testing must be received in good condition, and as far as possible should be in the same state as at the time when the sample was taken. It should be free from obvious dirt and show no signs of curdling. For bacterial examinations the milk should have been handled so that the bacterial content on arrival at the laboratory, with respect both to type and quantity of organisms will be approximately the same as at the sampling time.

Sample Containers and Method of Sampling.

Sample containers should be made from glass preferably with either a well-fitting screw top with cork inner or a ground glass stopper. Sufficient of the sample should be supplied to enable the test to be performed and to allow a surplus in case a duplicate analysis is necessitated. With chemical samples for the determination of butterfat content and total solids, a 2 oz. bottle, approximately two-thirds filled is sufficient. It is important that the bottle should not contain more than about two-thirds of its capacity in order to allow of shaking to ensure proper mixing. For the majority of bacterial samples a 1 oz. bottle is sufficient and for purposes of comparison, an ordinary vanilla essence bottle will contain a little more than 1 oz.

Many troubles associated with milk can be diagnosed from the odour of the sample without resort to any actual chemical or bacterial investigation. Bearing this in mind, it will be appreciated that containers must be scrupulously clean and free from foreign odours. Frequently samples are received at the laboratory in incompletely washed medicine bottles, tomato sauce bottles, and marmite jars. Milk very readily takes up odours and by the time the sample has reached the laboratory those odours associated with specific defects are completely masked by the odour of the previous contents of the bottle.

In taking a sample the object is to obtain a portion of the milk which is representative of the bulk supply. In order to achieve this it is necessary to ensure that the milk supply is thoroughly mixed. For chemical samples thorough mixing is obtained by means of a metal plunger which is operated in such a way as to produce both a circular and an up-and-down movement at the same time. A similar plunger, if it is sterile, may be used for bacterial samples, but in practice when a number of such samples are to be taken, it would be too cumbersome to carry several sterile plungers.

In these instances the sample is obtained by means of a "trier" consisting of a glass boiler tube between ¼ in. and ½ in. diameter and approximately 3 ft. to 3 ft. 6in. in length. This tube before sterilisation is lightly plugged at one end with cotton wool, and for the purpose of taking the sample, is inserted into the container so that a column of milk is taken right through the sample. The "trier" should be introduced slowly so that the milk will rise in the tube at approximately the same rate as that at which the "trier" is inserted. When the "trier" is resting on the bottom of the container the thumb or forefinger of the operator is placed over the end of the tube, which permits of the sample being withdrawn and delivered to the bottle.

For both chemical and bacterial samples the same type of apparatus is used for sampling, but different treatment is necessary. For the producer or consumer forwarding samples direct to the laboratory, apparatus similar to that described above will not be available. However, for chemical determinations adequate

mixing may be obtained either by agitation with a spoon, or preferably by pouring several times from one container to another. For bacterial analyses the system of pouring between containers is not permissible because of the possibility of contamination of the original material. Methods of mixing for these bacterial examinations are suggested later in the article.

Chemical Samples.

Within reasonable limits, sterility of apparatus is not essential where chemical tests only are to be performed. It is necessary, however, for all equipment to be clean and free from grease. Where the addition of a preservative will not hamper subsequent tests which will be performed it is desirable to add a small quantity which will ensure that the sample will be received in good condition. For ordinary fats and solids determination the use of formalin is recommended and this is usually obtainable from a local chemist. In summer time a 2 oz. container should be treated with two drops of formalin from an ordinary eye-dropper, and in winter time one drop will suffice. After this treatment, if the milk is forwarded immediately, the sample will, in the majority of cases, reach the laboratory satisfactorily.

Bacterial Examinations.

Complete sterility of all apparatus is essential if proper results are to be obtained for milk submitted for bacterial examinations. Apparatus supplied to officers sampling regularly is sterilised in the laboratory either by dry heat treatment or autoclaving. When dry heat is used the apparatus is subjected to a temperature of 180°C. for two hours, and when autoclaving, a steam pressure of 15 lbs. is used for 20 minutes. Sterile plungers are not used because of their bulk, but by mean of agitation with the sterile "trier" and its proper introduction into the can, a suitable sample is obtained.

For producers and home consumers where laboratory methods of sterilising are not available, the best that can be hoped for is that the containers and other equipment will be partially sterilised by means of boiling water. It will be noted that the word "partially" is used as it would not be correct to say that complete sterility is obtained by means of boiling alone. Many persons take considerable care with the cleansing of small domestic milk cans and bottles which are used to receive milk from the local dairyman. The containers are thoroughly washed in cold water and then boiling water, and all this good work is very often destroyed when the can is finally wiped either with a dish cloth or other rag. By this means contamination is re-introduced. It is recommended that the sample bottle, the can which will receive the bulk supply, and a spoon, be thoroughly boiled, and in the case of the bottle and can these should be inverted and allowed to dry, without wiping, in a still atmosphere free from dust. The spoon should be boiled preferably just prior to taking the sample. As soon as the can and bottle are dry, the lid and stopper should be replaced. By means of the boiled spoon the sample may be mixed and then carefully poured from the can into the sample bottle. If a piece of glass tubing is available and this has been boiled the sample may be sucked up into the tube and delivered to the bottle. This is preferable to pouring from a can, but it is advisable to plug lightly the end of the tube which does not enter the milk, with a clean piece of cotton wool.

Temperature of Sample.

It is imperative that as soon after sampling as possible the temperature of the milk should be reduced to 40° F. and the sample forwarded to the laboratory immediately. Where ice is available the sample container should be surrounded by ice and carried to the laboratory in this condition, or, failing this, cooled as rapidly as possible and delivered to the laboratory without delay. The temperature factor in the holding of milk is of paramount importance as bacteria multiply very rapdily even at winter room temperatures. If milk is not maintained at a low temperature, the whole bacterial picture would be altered and distorted even within half an hour.

Mastitis Samples.

Wherever possible the laboratory prefers to supply its own bottles to persons requiring microscopic examinations for mastitis. These notes do not apply to the test where experimental animals, such as guinea pigs, are used for the identification of this disease. In cases where it becomes necessary to perform this type of test it is advisable to communicate direct with the Veterinary Branch of the Department of Agriculture.

Where milk is to be examined microscopically for mastitis a sterile chemical is added to the bottle, which stimulates the growth of the mastitis organisms and this permits of a more readily available method of identification. When sampling for mastitis, the udder and teats of the animal and the hands of the person taking the sample should be washed thoroughly, and cleansed with a suitable disinfectant. The first few jets from each quarter should be discarded into a container and not on to the floor of the milking shed. The milk from the four quarters should then be directed into the sterile bottle, or if an examination of each individual quarter is required, a separate sample taken.

By holding the neck of the bottle close to the teat little difficulty will be experienced in obtaining a sample, but it should be remembered that when the top is removed from the bottle, this should not be placed on the ground or a bench. It should be held in the same hand as the bottle, with the top of the screw or ground glass stopper uppermost. This precaution applies to both bacterial and chemical analyses and the top should only be removed for the time immediately required for sampling, in order to reduce bacterial air-borne infection to a minimum. With chemical examinations this precaution is necessary to avoid evaporation of formalin or any other preservative used.

CONCLUSION.

In the preparation and submission of samples for chemical testing, if the proper precautions of mixing are observed and a preservative added, little difficulty will be experienced in obtaining a satisfactory result. However, with bacterial samples, unless these are taken with proper equipment and by persons who have been trained in the handling of this equipment, it is very difficult to carry out an efficient and conclusive examination. It is recommended that wherever possible, officers of the controlling bodies be approached when a sample for bacterial examination is required.

These notes on sampling have been prepared in the hope that more satisfaction may be obtained both by the person submitting milk and by officers of the Dairy Laboratory who are performing the analyses.

Mineralogy of some Soils from the Margaret River District.

Dorothy Carroll, Ph.D., D.I.C., Mineralogist, Government Chemical Laboratory.

INTRODUCTION.

As the second in this series of papers dealing with soil mineralogy of various parts of the State, this paper describes soils from the Margaret River district in which "falling disease" occurs. These soils were investigated at the suggestion of the Veterinary Pathologist (Dr. H. W. Bennetts) who, with Mr. H. T. B. Hall (1939), described the "falling disease" and later proved it to be due to copper deficiency. The results of the examination of a number of soils and rocks from the area between Metricup in the north and Forest Grove in the south provide information of the type of country in which this disease occurs.

GEOLOGY AND PHYSIOGRAPHY.

The township of Margaret River (lat. 33deg. 57min. S, long. 115deg. E) is situated 186 miles by rail south of Perth between Capes Naturaliste and Leeuwin, and is the centre of one of the Group Settlement Schemes started after the 1914-18 war. Prior to settlement it was heavily timbered with jarrah (*Eucalyptus marginata*), marri (*E. calophylla*) and with isolated patches of karri (*E. diversicolor*). The area is a slightly dissected peneplain, varying in height from 100ft. at Augusta to 427ft. at Cowaramup. Some erosion had been caused by the Margaret River, by other small streams flowing to the west and by streams flowing east or south-east into the Blackwood River. The area was at one time covered by a capping of laterite which was formed as a soil after peneplanation (Prescott, 1931, p. 46). This laterite capping has been partially removed by stream action which has exposed the country rocks and initiated a further period of soil formation. The rocks of the area are early Pre-Cambrian gneisses. The Coastal Limestone series (Jutson, 1931, p. 23) partly covers the eroded western edge of the peneplain. On superficial inspection the soils can be divided into three main types: lateritic, with residual lateritic pebbles and sometimes underlain by massive laterite; sandy loams grading into clay loams without lateritic pebbles; and sandy soils with very little clay or silt.

THE SOILS EXAMINED.

General geological observations were made between Metricup and Forest Grove, principally west of the main Busselton-Augusta road in the area described by Bennetts and Hall (1939) as affected by 'falling disease." Soils and rocks were collected from six farms which had been examined by Bennetts and his colleagues in considerable detail and for which histories of the mineral deficiency were available. On three of these farms there is severe mineral deficiency which has resulted in "falling disease" in dairy cows, but on the other three, which are close to the "deficient farms," the nutritional conditions appear to be better and the farms are described as relatively sound although some degree of deficiency appears to be general throughout the area surveyed. The soil samples are in almost every instance surface soils taken to an approximate depth of 9in. The soils generally appeared to be rather thin and rock outcrops were plentiful. (Positions are shown on Lands Department lithos. $\frac{413D}{40}$, $\frac{440A}{40}$, $\frac{440D}{40}$)

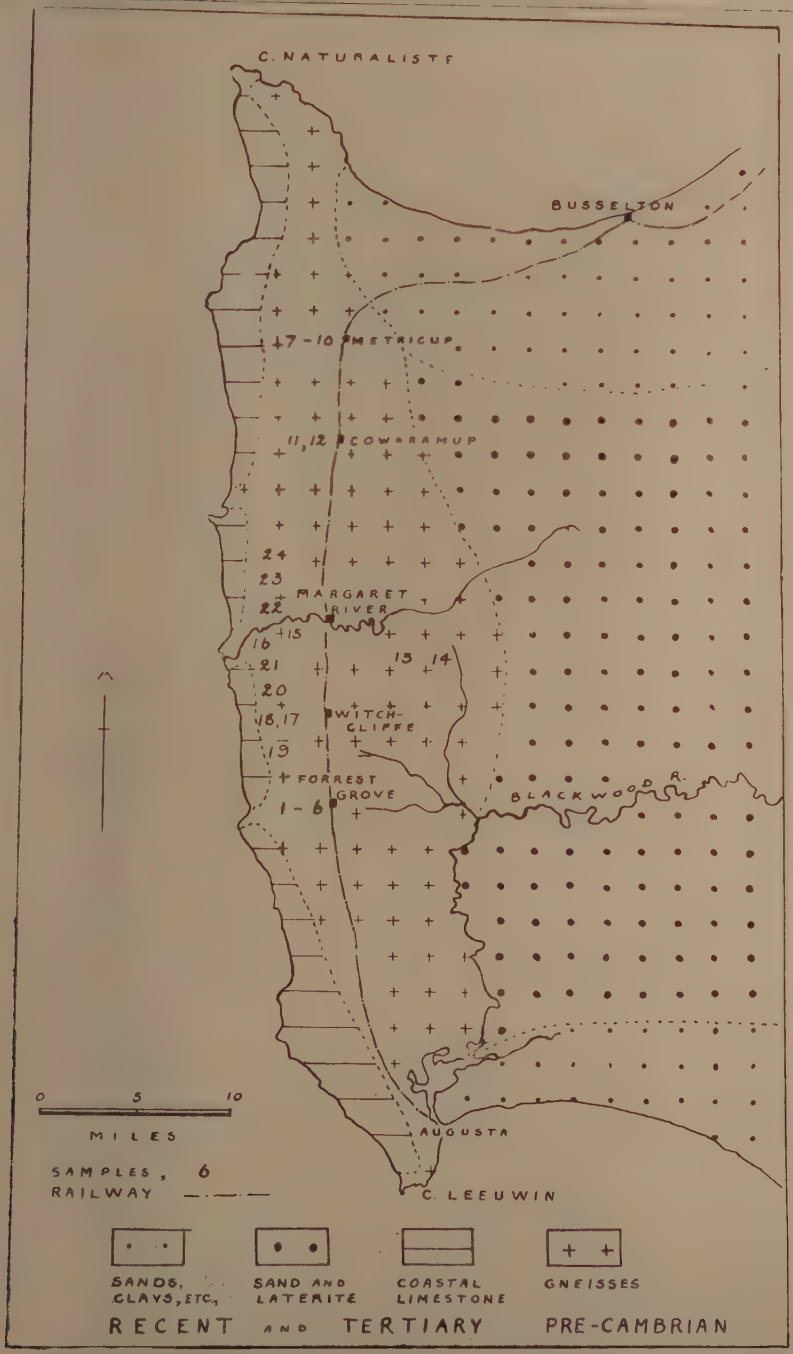
The following is a list of the localities from which soils and rocks were collected:—

No. of Sample.	Locality.	Description.	Remarks.
1	Forest Grove, Loc. 1626	Lateritic soil with abundant hard masses of laterite containing angular quartz fragments, and much sand	Unsound.
2	Forest Grove, Loc. 1625	Brown sandy soil with a few lateritic pebbles	do.
3	Forest Grove, Loc. 1558	Grey sandy soil with much coarse sand	do.
4	do. do. do.	About 1 ft. soil underlain by massive laterite and weathered gneiss	do.
5	Forest Grove, Loc. 1634	Brown lateritic soil from near creek	Relatively sound.
6	do. do. do.	Good depth of yellowish-brown clayey friable soil with a little lateritic gravel	do. do.
7	Metricup, Loc. 1680 ...	Brownish sandy soil from near gneissic outcrops	Unsound.
8	do. do. ...	Heavy yellow sandy clay soil ...	do.
9	Metricup, Loc. 1678 ...	Light greyish-brown non-lateritic soil, fairly deep	Relatively sound.
10	Metricup, Loc. 2198 ...	Sandy soil from near gneissic outcrops	No records.
11	Cowaramup, Loc. 2088	Pale brownish-grey soil, lateritic ...	Unsound.
12	do. do. do.	Grey sandy soil with very little clay	do.
13	Rosa Brook Road, near Loc. 2164	Brown loam with a few lateritic pebbles	Relatively sound.
14	Rosa Brook Road, 0·8 ml. W. of S.W. corner of Loc. 1905	Brown loam near gneissic outcrop ...	do. do.
15	Carter Road	Red friable soil near gneissic outcrops	No records.
16	Near corner of Carter and Yallingup Roads	Brown sandy loam and gneiss from large bluff	do.
17	Witchcliffe Road, 3·2 ml. W. of Augusta Road	Grey sandy soil and gneiss from outcrop	do.
18	Witchcliffe Road, 4·2 ml. W. of Augusta Road	Brown sandy loam, gneissic outcrops	do.
19	Caves Road, just S. of junction with Witchcliffe Road	Garnetiferous gneiss	do.
20	Caves Road, 1·3 ml. N. of Witchcliffe Road junction	do. do.	do.

Teakle and Turton (1943) give the copper status of clover samples from a number of properties in the district. The figures vary from 1.0 ppm. for clover growing on a brown sandy soil at Forest Grove to 12 ppm. for clover on an apparently similar type of soil at Metricup. The copper content of clovers from properties examined in this paper are:—

	Cu. ppm.
Wilkinson, Metricup Loc. 1680	2.2 and 5.4
" " "	8.3
" " "	5.1
Rapson, Cowaramup Loc. 2088	1.8
Millar, Forest Grove (opposite Loc. 1558 and 1625) ..	1.0

Excluding the two highest figures obtained (12 and 8.3 ppm.) the average copper content of the clovers is 3.65 ppm. (11 samples) and the soils therefore fall into the subnormal or deficient group. (Teakle and Turton, 1943, p. 245.)



Geological Sketch-map of the Naturaliste-Leeuwin area, showing positions of samples described in the text. (Geology partly after E. C. Saint-Smith, Geol. Survey, W. Aust. Bull. 44.)

METHOD OF EXAMINATION.

Soils.—The soils were prepared for microscopic examination by the method described in a previous publication (Carroll, 1944, p. 86).

Rocks.—The rocks were examined in thin sections.

MINERALOGY OF THE SOILS.

The following heavy minerals were identified in the soils examined:—Magnetite, ilmenite, leucoxene, amphibole, zircon, rutile, tourmaline, garnet, sphene, silimanite, monazite, kyanite, staurolite, xenotime and spinel. The light fractions consist of quartz and felspar with a little clay. The distribution of the heavy minerals and the figures for heavy and magnetic fractions are given in table I. It should be noted that both heavy and magnetic fractions are higher in these fine sands than they are for most soils examined from other localities. (Carroll, 1944, pp. 91-93.)

The heavy residues of the fine sands do not contain a great variety of minerals and are characterised by the abundance of magnetite and zircon. The lack of variety is caused by the derivation of the soils from a series of rather similar gneisses. It is considered that the soils are formed *in situ* from the underlying rocks.

Description of the Individual Minerals.

The opaque minerals, magnetite, ilmenite, leucoxene, etc., are similar to those occurring in many types of soil and need no further description.

Rutile is present only in small quantities and occurs in rather large, somewhat rounded, deep reddish-brown grains.

Zircon occurs as clear colourless grains with a few large bleb-like inclusions. There are no brown or purple grains and only a very few zoned grains. Although so plentiful, the zircon is actually of one, or at most, two types. It is unusually abundant in the rocks of the area and quite large grains are seen in the thin sections.

Amphibole is present in a number of the soils, particularly those adjacent to outcrops of gneissic rocks containing hornblende. The green amphibole is weakly magnetic, one soil (No. 2) containing one per cent. in the fine sand. This amphibole has Z = brownish-green, X and Y = almost black, Z $\wedge$ c is very small. Amphibole from other residues has Z $\wedge$ c = 34°, 27°, 15°, and the pleochroism may be pale olive-green to almost black. Colourless amphibole is not plentiful and is definitely subordinate to the green when is occurs in the same residue. It has generally only a small extinction angle. Thin sections of the rocks of the area show that the amphiboles conform to one or two types which are also found in the soils.

Kyanite is a very minor constituent in a few of the residues, and exhibits no unusual features.

Silimanite occurs as a few grains only in a number of the residues.

Staurolite is similar in occurrence to sillimanite and is even less plentiful.

Garnet occurs in a number of the residues as typical fresh pink and occasional colourless grains which have suffered no transport or abrasion. Garnet is generally present in small amounts only, which indicates that none of the soils examined is derived from garnetiferous gneisses. It is weakly magnetic.

Sphene in typical pale yellow-brown grains occurs in a number of these residues.

Three other minerals which are of minor occurrence are spinel, monazite and xenotime. These minerals are very often associated with gneissic or granitic residues in Western Australian soils.

The light fractions consist essentially of quartz with a fair amount of felspar among which microperthite predominates, but orthoclase and plagioclase felspars are often present. In some fine sands felspar makes up about half the sand and is generally fresh and unweathered. The quartz is angular to well-rounded, the rounding not being due to abrasion in the present cycle of erosion, for quartz is seen to be spherical in the solid gneisses. This shape is probably the result of abrasion in a sedimentation cycle prior to the formation of the gneisses which are partially of sedimentary origin. Such rounded grains occur in thin sections of rocks Nos. 7, 13, 15, 17. Clay occurs in some of the light fractions as large grains and aggregates which did not wash out during the preparation of the fine sand. In some sands these clay mineral grains are recognisable as altered amphibole or pyroxene, but generally these grains are brownish-green with a refractive index above 1.54, apparently belonging to the nontronite end of the nontronite-montmorillonite series.

Rocks.—The rocks which appear to be associated with the soils are all gneisses of various types belonging to the early Pre-Cambrian group. The gneisses strike, generally, nearly north and south, but the strike swings from north-west to north-east, and the dip is to the east at varying angles. They are a folded series, and individual members occur as bands in some of which there are pegmatite phases and in others long parallel basic lenses. The following types of gneisses were collected in the district:—

1. Microperthite-quartz-plagioclase-amphibole gneiss (Nos. 2, 10, 11, 14, 16, 19).
2. Plagioclase and/or microperthite-amphibole-hypersthene quartz gneiss (No. 9).
3. Microcline-garnet-amphibole gneiss (No. 18).
4. Microline-garnet-quartz-biotite gneiss (No. 20).
5. Microcline-quartz-biotite gneiss (Nos. 21, 22, 23, 24).
6. Plagioclase-augite-quartz gneiss (No. 15).
7. Microperthite-quartz gneiss (No. 7).
8. Microperthite-hypersthene-quartz gneiss (Nos. 13, 17).

From the information available it is found that "mineral deficient" country is associated at Forest Grove and Cowaramup with type 1 and at Metricup with type 7.

Rock Weathering.—The Margaret River district is an area which, although enjoying a good rainfall, has been able to resist weathering and denudation because of its gently undulating nature. Over much of it there is a dense covering of laterite, the remains of a previous period of soil formation, which has only been partially removed. Where exposed, the country rocks are generally very little weathered and are not highly kaolinised as in some other parts of the State. In this present cycle of erosion and soil formation weathering has not reached any great depth. The heavy residues represent the resistant material of the rocks which have weathered to form soils. That these residues are so uniform in composition indicates that there is very little variation in essential rock types. The rocks vary only in small details, but that they do vary at all has probably considerable significance in the nutritional status of the soils produced. An example of this is found in samples 7 and 8 at Metricup, which are unsound soils, and in sample 9, from the adjacent holding which is much sounder. Soils 7 and 8 are underlain by a microperthite-quartz gneiss, whereas 9 is presumably derived from a plagioclase-

amphibole-pyroxene-quartz gneiss. The whole area examined is devoid of obvious basic dykes and seems also to be lacking in hornblende schists, both of which rock types produce soils of good nutritional value elsewhere. Generally granitic or gneissic rocks produce soils which are not as good nutritionally as those which are derived from parent material of mixed origin or from basic rocks.

CONCLUSIONS.

The mineralogy of soils and rocks from a few isolated localities in the Margaret River district has shown that the soils are derived from an interbedded series of gneisses. Work carried out by officers of the Department of Agriculture has shown that soils derived from gneisses are liable to be deficient in minor elements, and in this instance copper was the particular element lacking, the incidence of "falling disease" being due to the lower copper status of the soils. This paper gives the geological background to the investigations previously carried out.

As further investigations of the relationship between parent rocks and soils are made in the south-western part of this State it is becoming increasingly evident that the majority of the soils occurring on the uplifted peneplain, apart from those which are obviously alluvial or which owe their origin to movement of parent material, have developed *in situ* and consequently reflect the mineralogy of the underlying rock. This results in patchiness and the occurrence of many soil types in rather small areas. It follows from this, if the acreage held by any one farmer is small, that animals grazing will be confined to one or at most a few soil types, and that these animals will be living off the chemical elements which one or two rock-types are able to supply. Some rocks, because of their chemical composition and origin, are able to supply more of the required elements for nutrition than others. Animals grazing on nutritionally poor soils cannot get the required mineral elements for healthy growth, and this appears to be the cause of the so-called "falling disease" in this district.

ACKNOWLEDGMENTS.

This investigation was started under a Commonwealth Research Grant at the University of Western Australia in 1940, but owing to more pressing matters it could not be finalised until the second half of 1944 at the Chemical Laboratory. My thanks are due to Dr. H. W. Bennetts who suggested the actual farms where soil samples were collected and who visited these farms with Professor E. de Clarke and myself so that a complete picture of the conditions could be obtained. I wish to thank Professor Clarke for his invaluable help and advice during the field-work.

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TABLE I.

HEAVY MINERALS IN THE FINE SANDS OF THE MARGARET RIVER DISTRICT SOILS.

Locality	Forest Grove.						Metricup.				Cowaramup.		Rosa Brook.		Caves Road and Witchcliffe.			
Location No.	1626	1625	1558	1558	1634	1634	1680	1680	1678	2198	2088	2088	—		—			
Sample No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Heavy Fraction (%)†	14·1	10·2	11·4	8·2	14·0	17·8	11·3	15·0	26·7	13·2	19·2	10·6	*	22·7	12·0	28·0	10·8	25·2
Mag. Fraction (%)†	7·2	3·2	5·0	2·8	6·5	7·2	4·1	4·0	9·7	7·6	6·5	1·2	32·7	12·4	5·1	7·7	4·4	16·3
Ilmenite	A	+	A	+	+	A	+	A	+	+	+	+	A	+	+	+	+	+
Leucoxene	+	+	A	+	+	A	+	A	+	+	+	+	A	+	+	...	+	+
Rutile	+	+	+	S	S	S	+	+	S	+	S	S	+	S	S	S	+	S
Zircon	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Tourmaline	S	S	+	...	S	S	...	...	...	...	S	S	...	S	...	...	S	S
Amphibole Green	...	A	...	...	S	S	...	...	...	A	...	S	A	A	S	A	+	+
Amphibole Colourless	S	...	S	...	S	...	S	S	...	S	S	...	...	...	...	...	S	S
Kyanite	S	...	S	...	S	...	S	...	...	...	...	...	...	...	S	...	...	S
Sillimanite	S	+	...	...	...	...	...	...	S	...	+	...	...	+	S	...	S	S
Staurolite	S	...	...	...	S	...	...	...	...	...	...	...	...	...	...	...	S	S
Garnet	+	S	...	...	...	S	...	S	...	...	S	...	+	...	...	S	+	+
Sphene	...	S	...	...	+	S	S	+	+	+	+	+	S	S	S	S	S	...
Spinel	S	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	S
Monazite	...	...	...	S	S	...	...	...	...	...	...	...	...	...	...	...	...	...
? Xenotime	...	...	...	...	...	...	S	...	...	...	...	...	...	...	...	...	...	...

* Poor Separation, so no figure is given. † Percentage in fine sand. The heavy fraction includes the magnetic fraction. A = Abundant. + = Present up to 5 per cent. S = Few grains only.

The Rearing of Dairy Calves.

N. R. McKeown, Agricultural Adviser.

War has brought problems of varying complexity to all industries and all branches of industry, and of these dairying has shouldered its very fair quota. In each case, however, the problem of the moment has received considerable thought, and after a greater or lesser period of time either an adequate solution or a temporary expedient has been evolved. Nevertheless, at times, the most expeditious solution has not been in accord with the soundest policy for the future, and with possible food shortages looming ahead, plus a brightening prospect on the war fronts, modifications should be instituted to cope with the new conditions.

Such an instance is the rearing of dairy calves. In the early years of the war especially, dairy farmers found that they were fully occupied handling their existing herds and endeavouring to maintain their properties, without too much thought for the future of those herds, far less the future of the herds throughout the State. Manpower has been a serious problem, concentrates are short supplied, and the farmer has been exhorted to produce a maximum of pigmeats. Hence it is not surprising that the rearing of dairy heifers has received less attention than otherwise would have been the case. The temporary expedient adopted in the early years of the war was to cut down work as much as possible and abandon any activity which did not contribute immediately to the exigencies of the situation. Happily, the position is now slowly improving. The dairyman has still many difficulties but his fight is moving in the right direction and attention must be directed more and more to increased production and future reconstruction rather than to present maintenance alone. To this end it is essential that in addition to giving existing herds the best of possible feed and management, provision must be made for replacements and the nucleus of future herds. It is not sufficient that the farmer has enough heifers coming forward to make good natural wastage in his own herd, but in addition he should aim to rear every female calf from every cow whose production warrants a continued position in his own herd. As demobilisation proceeds many men will turn to the land for a living and of these a percentage will be attracted to an industry which offers regular returns for steady work—the dairying industry. New settlers may start on virgin land or reclaimed farms but in either case good healthy dairy stock will be required as soon as feed can be grown. The logical source of supply of such stock is from established Western Australian dairy farms, and this article is designed to encourage farmers to rear as many good heifers as possible, and to assist in rearing them.

Normally, when the supply of heifers is sufficient to meet the demand, emphasis would be laid on the advisability of rearing only those from the best cows. Replacement would only amount to approximately three heifers for every ten cows milked, and one or two would possibly be reared for sale. It must be recognised now, however, that such a programme would not provide an adequate number of cows to meet future needs, and calves whose dams have only average butterfat production to their credit should be retained. If they are later mated to good quality pure bred bulls such calves will, in most cases, constitute the modest beginning of future profitable herds. It is the breeder's responsibility to ensure that his young stock is well grown, yet despite the fact that this is a relatively simple matter, many dairy heifers do not warrant this description and suffer from digestive disorders which a little care and knowledge could easily prevent. Little more attention is necessary to rear a calf that will be a credit to the stockman than to rear a stunted animal which will reflect adversely on his management.

The Dam.

The first step taken by the farmer to ensure a strong healthy calf is to ensure the well-being of the in-calf cow. In the early stages of pregnancy the usual routine feeding and management of the milking cow is quite sufficient, but provision must also be made for the adequate nourishment of the cow and foetus when the lactation is terminated.

This usually occurs at the worst season of the year, a circumstance which is economically sound if the cow is plentifully supplied with pasturage and good quality home-grown roughage enabling her to produce a healthy calf and build up her own body reserves for the ensuing lactation. When the cow starts to spring she should be segregated in a sheltered paddock handy to the homestead, so that at calving she will be free from the interference of other stock. In the majority of cases cows will calve quite normally and the farmer should not render assistance unless he has good reason to believe that such is warranted.

Fig. 1.
The delicate age (first four weeks).

Separation of the Calf from the Dam.

There is some difference of opinion concerning the time that the calf should be left with its dam but the most usual period is from 24 to 48 hours after birth. This ensures the calf receiving the first milk or colostrum under natural conditions and helps to relieve any congestion of the udder without permitting the growth of undue affection between calf and dam. This period need not be rigidly adhered to, and if the calf is small and weak it may be advisable to increase the time to three or four days; or if the udder is abnormally inflamed and congested it may be better to leave the calf with the cow until the condition has cleared up. Generally speaking, however, the longer the calf is left with the dam, the greater is the difficulty in teaching it to drink from the bucket, and the greater will be the attachment between the pair.

Irrespective of the time the calf sucks the dam it should receive its mother's milk for at least seven days. The colostrum is especially suited to the requirement of the young animal, being particularly rich in vitamin A, and containing more minerals, and a higher percentage of easily digestible protein than ordinary milk. In addition, it acts as a purgative and assists to immunise the calf against certain infectious diseases. If the dam of a valuable calf dies at birth, an endeavour should be made to obtain some colostrum from another newly calved cow.

Teaching the Calf to Drink.

On removing the calf from its mother it should be sheltered in a clean, dry shed and permitted to get fairly hungry. At least 12 hours should elapse before attempting to feed the calf from the bucket, by which time it will show a definite interest in the proceedings. If the fingers are then dipped in the milk the calf will

usually suck them, and if the head is gradually lowered and the bucket slightly raised will soon suck the milk up past the fingers. Once the calf has become used to this method of drinking, the fingers may be slipped out of the mouth and the calf will drink alone. The sooner this stage is reached the less time will be wasted by the farmer. Patience is the keynote in teaching a calf to drink.

Feeding the Calf.

It is the general practice of the dairyman to rear calves by hand, and because as a rule the milk of the dairy cow is worth more than the calf, it receives the first consideration. For economic reasons a minimum of whole milk is usually fed and the basis of the ration becomes either skim milk, where cream or butter is sold, or milk substitutes when whole milk is delivered for market purposes or to a cheese factory or condensery.

Fig. 2.
The skim-milk age (one to six months).

Raising Calves on Skim Milk.

Though some breeders prefer to rear valuable calves on whole milk it is an established fact that an equally sound dairy animal may be raised on skim milk provided an ample supply is available. Separation only removes the fat from the milk, and this constituent serves primarily to supply vitamin A., heat, and fat for the body tissue, not to promote growth. Young leafy pasture plants contain the precursor of vitamin A. and crushed oats or other readily digestible grains will supply heat and fat at far less cost than whole milk. The calf fed on skim milk may not appear so sleek and attractive for the first six months of its life, but as a yearling there will be little, if any, difference between a calf so fed and one fed on whole milk.

The following results obtained in an experiment on the feeding of calves, conducted at Woburn in England, compares several methods of feeding calves:—

TABLE 1.

Group.	Food.	Gain per Calf per Week. lb.	Cost per lb. gain in live Weight. pence
Lot 5	Separated milk plus crushed oats fed dry ..	13.30	2.52
Lot 4	Whole milk	12.83	2.39
Lot 2	Purchased calf meal in separated milk ..	8.66	2.77
	Gruel (linseed and oatmeal) in separated milk	8.33	3.45

All calves received whole milk for the first three weeks.

Number of Feeds per Day.

The young calf normally takes its milk from the dam frequently and in small quantities, and therefore feeding three or four times per day is often recommended, but in practice it has been found that hand reared calves thrive well when fed only twice a day. If the calf is weak thrice daily feeding may be advisable for a short period. In general, feeding twice a day fits in readily with the dairy routine, the milk is more easily fed at the right temperature, and utensils can be cleaned and scalded with the rest of the dairy equipment. If a midday feed is given, the milk should be protected against deterioration and warmed just prior to feeding to a temperature between 95 deg. F. and 100 deg. F., and the buckets washed immediately after feeding.

Times of feeding should be approximately the same each day.

Quality of Whole Milk Fed.

It has been shown by past experience that calves thrive best when fed clean, warm, whole milk testing about 3.5 per cent. of butterfat. Richer milk may be diluted to approximately this test with warm water. Milk containing 3.5 per cent. of butterfat is readily digestible and provides a standardised ration when a definite feeding schedule is followed. As there is a general correlation between the fat test and the solids—not fat in milk, a milk which supplies more fat will also supply more protein and carbohydrate per lb. than the calf requires. A high testing milk forms a hard curd in the stomach which is difficult to digest, and may give rise to digestive disorders.

The following dilutions for milks of various butterfat percentages are suggested by A. C. T. Hewitt (1) :—

To 10 lb. of 3 per cent. milk add no water; to 10 lb. of 3.5 per cent. milk add no water; to 10 lb. of 4 per cent. milk add 1½ lb. of water; to 10lb. of 4.5 per cent. milk add 3 lb. of water; to 10 lb. of 5 per cent. milk add 4½ lb. of water; to 10 lb. of 5.5 per cent. milk add 6 lb. of water; to 10 lb. of 6 per cent. milk add 7½ lb. of water. If boiling water is added it also assists in raising the temperature of the milk, but this should be checked before feeding the milk to the calf. The temperature should be uniform for all feeds and the feeder should use a thermometer at frequent intervals to check his judgment as to blood heat.

Quantity of Milk to Feed.

For the first week 8 to 10 lb. of its mother's milk (diluted to 3.5 per cent. butterfat) is adequate for the largest calf, and 6 to 8 lb. for a smaller calf such as those of the Jersey breed. The second week the same quantity of 3.5 per cent. milk should be fed but it need not necessarily come from the dam. Commencing at the age of two weeks, if the calf is thriving, a small quantity of skim milk may be substituted for whole milk and the quantity raised by 2 or 3 lb. More skim milk may replace the whole milk in the fourth week, the calf receiving from 15 to 17 lb. of milk of which a third is whole milk and the balance skimmed. In the succeeding week the skim milk may be increased a further 4 to 5½ lb. and the whole milk reduced by 3 lb. From the sixth week until weaning the calf should be receiving up to 22lb. of skim milk, plus supplementary feeds such as grain, pasturage and hay.

Supplements to Skim Milk.

For this purpose an easily digested starchy food is required. Skim milk is very rich in protein—the albuminoid ratio is 1 : 1½ as compared with whole milk 1 : 4. The best supplements consist of whole or crushed cereal grains, oats being a very popular constituent. Wheat bran adds to the palatability of a ration, and is much used for this reason.

Commonly used supplements which may be recommended are:—

1. Crushed or whole oaten grain.
2. Equal parts of crushed oats and crushed wheat.
3. Equal parts of crushed oats and wheaten bran.
4. Nine parts crushed oats, three parts crushed wheat and one part linseed meal.

The practice of adding appreciable quantities of protein rich foods to skim milk for feeding young calves is to be discouraged. Additional protein is unnecessary, expensive, and may give rise to serious digestive trouble. Linseed meal in small quantities, however, is much relished by calves and encourages them to eat the meal in the early stages of feeding. Linseed meal also has a tonic effect on the system and is especially valuable when no green feed is available, but should on no account constitute a major part of the skim milk supplement.

Fig. 3.
The oft-neglected age (6 to 15 months).

Method of Feeding the Supplements.

Calves should be taught to eat grain as soon as possible and will generally do this quite well by the time they are three weeks old. In the third week the calf should be tried with a handful of dry grain placed in the bottom of the bucket after it has drunk its milk. If a small quantity is put in the calf's mouth it will get the taste of the grain and take to it more readily. Later the calf will look for the grain and it may be fed in a box or trough separately from the milk. At six weeks old the calf will eat about ½ lb. of grain per day, at the end of two months 1 lb. per day, and at the end of three months 2 lb. per day. This daily ration will be quite sufficient until the calf is six months old. Grain should always be freshly supplied, and no unconsumed grain left in the feeding box.

Pasture Hay and Silage.

Hay and good pasturage are important components in the ration of the growing calf. Legume hays are preferable to grass hays from a nutritional viewpoint as they contain more minerals and proteins for building the young body, but where there is any tendency to scour, grass hay is less likely to exaggerate the

condition. The laxative effect of legume hays is usually associated with well cured, bright, leafy hay of good quality, little trouble being experienced if the hay is of poorer grade. For the calf up to three months of age, good hay is generally considered to be preferable to pasture grass as roughage, due to the laxative nature of the grass. From the age of approximately three months onward access to grass can definitely be recommended. Where a plentiful supply of grass and hay is available in conjunction with ample skim milk, very little grain will be required.

Fresh silage of the best quality may be fed in limited quantities to calves after they are two months old. Before this age the calves will not eat an appreciable quantity, and that little will quite probably disagree with them.

Weaning.

Where skim milk can profitably be utilised in the production of pigs there is little advantage in feeding calves on skim milk beyond the age of six months. At this age the calf is able to eat sufficient other foodstuffs to maintain its growth

FIG. 4.
The breeding age (15 to 22 months).

unchecked. To ensure this and prevent digestive upsets, however, the weaning should be gradually effected. It is advisable to feed half the quantity of milk for five to six days, then the remainder may be halved and, if no ill effects are experienced, milk feeding may be discontinued in four or five more days.

After Weaning.

This is a critical period during which many heifers are neglected. Rate of growth must be maintained by feeding ample roughage either in the form of pasturage or hay. Legumes, both green and as hay, are particularly valuable to young stock at this time. Suitable phosphatic licks or finely ground bonemeal should be supplied to make good any deficiency of phosphorus or calcium in the fodder.

Do not mate heifers too young. The best breeding age is between 15 and 20 months.

Raising Calves without Skim Milk.

This problem is faced by farmers who either sell their milk as whole milk or deliver it to condenseries or cheese factories. To separate sufficient milk for the

feeding of calves is not a practical solution and the utilisation of whole milk for this purpose is far too costly. The method most commonly used is possibly the feeding of a small quantity of whole milk in conjunction with "milk substitutes" either in the form of a commercial calf meal or a home mixture fed as a gruel.

Milk Substitutes.

Any mixture designed to replace milk in the calf ration should comprise ingredients which are readily digested, palatable, of a similar chemical composition to milk, and of reasonable cost.

The following mixtures of concentrates have been used quite successfully as gruels by mixing 1 lb. with 9 or 10 lb. of water in each case:—

1. Three parts pollard to two parts linseed meal.
2. Three parts pollard to two parts skim milk powder.
3. Two parts pollard to two parts linseed meal and one part crushed peas.

All the above proportions are by weight.

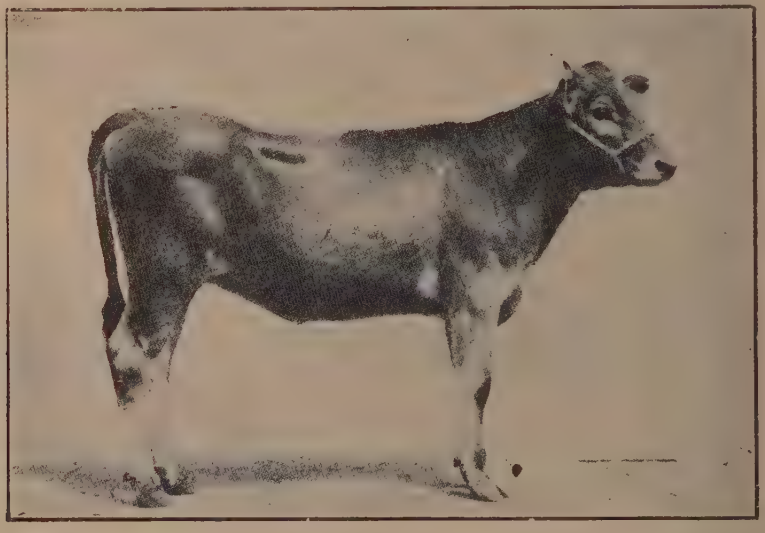

Fig. 5.
Yearling heifer in good growing condition.

Where leguminous grains can be obtained, the last mixture will probably prove better than the first though not quite as good as the second. Crushed peas and beans are of great value to young stock due to the high quality of the protein which approaches more nearly that of animal origin than that from any other vegetable source.

Experiments have shown that neither proprietary meals nor home mixtures are entirely satisfactory as complete substitutes for milk in the calf ration, but when fed as milk supplements they have proved fairly satisfactory. Any milk substitutes of a cereal nature will be low in vitamins A. and D. and, unless blood meal or powdered skim milk is used in addition, the quality of the protein will not be high, and the supply of minerals will be particularly low. Calves will often do quite well on gruel alone when ample green succulent pasturage is available.

Success in the use of these meals will therefore depend on getting the calves well started on a milk diet and continuing the use of milk, where possible, in a limited way until the animal is able to utilise enough meal, grain, hay, etc., to continue its growth satisfactorily. The feeding of dry meals should replace the more troublesome gruel feeding as early as possible.

Whey.

Where milk is supplied to a cheese factory, the whey is usually made available to the farmer and is used to a limited extent in calf rearing. Whey returned from the factory is often too highly fermented to be suitable for feeding to calves, but if pasteurised at the factory may be secured in an unfermented condition. If whey is not pasteurised, it should be boiled before use. Fed with suitable concentrates whey will produce calves which are almost as thrifty as those fed on skim milk. Gruels may be made by using ½ lb. of any of the mixtures previously listed mixed in one gallon of whey. If pollard alone is to be fed with whey, it should be in the proportion of 1 lb. pollard to 10 lb. whey.

Fig. 6.
Heifer too low in condition.

Due to the high protein content of skim milk the supplementary concentrates recommended are of a carbonaceous character such as the cereal grains. Whey is very low in protein but rich in carbohydrate, therefore protein rich supplements like crushed peas or linseed meal should be used.

Feeding Schedule.

Irrespective of the milk substitute to be used later, the calf should receive new milk (3.5 test) twice daily at the rate of 1 lb. to 10 lb. of body weight for at least the first two weeks, then it may be transferred to the chosen substitute. If whey is to be fed it is preferable to extend this period to at least four weeks. The quantities of gruel fed per day may then follow the schedule already outlined for skim milk.

Use of Dry Meals.

The methods used are essentially the same as described for calves fed on separated milk. During the third or fourth week, commence placing a little dry

meal in the bottom of the calf's bucket after the gruel has been consumed. As the taste for the concentrate is acquired, increase the ration and feed proportionately less meal in the liquid form. It is better to dilute the gruel than to decrease the bulk supplied, as calves should be encouraged to drink ample water. Readily accessible supplies of fresh water should always be available to young calves. Three mixtures may be suggested for this purpose which should give satisfaction, especially when fed with leguminous hays and pasturage.

(a) Equal parts of crushed oats and linseed.

(b) Linseed meal .. .. 1 part by weight.
Crushed oats .. .. 1 part by weight.
Wheat bran .. .. 1 part by weight.

Fig. 7.—Heifer carrying too much condition.

If crushed peas or beans are available, a well balanced meal may be prepared as follows:—

(c) Bran .. .. 3 parts by weight.
Peas .. .. 2 parts by weight.
Crushed oats .. .. 2 parts by weight.

A little linseed meal may be added to this last mixture to increase the palatability.

The following mixture which may be used dry as a meal or made up as a gruel was cited by the N.S.W. *Agricultural Gazette* (2) in an article on the feeding of milk substitutes based on experience in the United States and Great Britain.

	Per Cent.
Dried skim milk or butter milk	20
Bran or crushed oats	18
Crushed wheat, barley, maize or pollard	40
Linseed meal, coconut meal or peanut meal	20
Bone meal	1
Salt	1
	100

The milk product should not be reduced below about 20 per cent. and if the material is available it should be increased to 30 per cent. Some oil meal, preferably linseed meal, should always be included in the mixture.

The following is a summary of a suggested method of feeding, using whole milk and gruels, about 15-20 gallons of whole milk being used per calf. The gruel may be made up as previously by mixing 1 lb. meal with 10 lb. water.

First two weeks.—Colostrum and whole milk on a basis of about 1 lb. of milk per 10 lb. live weight.

Third to fourth week. Commence the third week with about three quarts of whole milk and one quart of gruel per day, gradually increasing the proportion of gruel till at the end of the fourth week whole milk has been completely replaced by gruel. Also, at the beginning of the third week, introduce a little dry meal, as used for making the gruel, and lucerne hay.

Fifth to sixth week.—Feed four to five quarts of gruel per day and allow access to dry meal.

Seventh to eighth week.—Reduce the gruel gradually, allowing plenty of water to make up for the fall in liquid intake, and increase the hay and meal allowance as the gruel is decreased. At the end of the the eighth week gruel can be eliminated and the calves may be allowed up to 2 to 2½ lbs. of meal per day.

After the eighth week calves may be raised on meal, hay and pasture. At 12 weeks the milk product may be dropped from the meal, but it is preferably continued until four to five months.

The following summarises the feeding on whole milk and meals, about 35 gallons of whole milk being used per calf:—

One to three weeks. Colostrum and whole milk, introducing a little meal and hay towards the end of the third week, by which time calves should be receiving about 8 to 10 lb. of milk per day.

Fourth week.—Whole milk, three quarts; meal, ¼ lb. per day.

Fifth week.—Whole milk, three quarts; meal, ¼ lb. to ½ lb. per day.

Sixth week.—Whole milk, two quarts; meal, ½ to to ¾ lb. per day.

Seventh week.—Whole milk, two quarts; meal, ¾ lb. to 1 lb. per day.

Eighth week.—Whole milk, one quart; meal, 1½ lb. to 2 lb. per day.

Ninth week.—Meal only.

Again at 12 weeks the milk product may be dropped from the meal mixture. Of course, if desired, the meal could be given in the form of gruel.

Minerals.

Nutritional research has shown that the growing animal should be plentifully supplied with phosphorus and calcium. This may be accomplished by allowing the calves access to finely ground bone meal. Salt, too, should be made available when the calf is old enough to eat grain and hay.

The foregoing discussion on feeding, including examples of rations fed under different circumstances, is written to form a guide which the stockman may follow, but not as a set of rules to be rigidly adopted. The rations are not definite standards, but may be adjusted within reason in relation to the size and health of the calf and the available foodstuffs and their cost. The quantity of milk, meals and grains to feed is ever largely dependent on the nature, quality and quantity of the roughage available.

GENERAL MANAGEMENT.

Cleanliness.

This should be observed at all times in connection with any phase of calf rearing. Many forms of sickness in hand raised calves may be attributed directly to unclean methods. All utensils used in feeding should be washed and scalded as soon as possible after use. No distinction should be made between the cleanliness of buckets used for milking and those used for the calves. Feed boxes and troughs for other feeds should be kept scrupulously clean, and no grain, hay, etc., permitted to accumulate and ferment.

Milk fed to calves should always be sweet and clean and for this reason it is advisable to feed the milk as soon as possible after milking. If it is necessary at any time to feed milk from cows suffering from an udder infection, such milk should be boiled prior to feeding.

Fig. 8.
Calves reared under good conditions.

Calf pens should be cleaned out regularly—daily if possible—and the pens so constructed that they are dry, warm and admit a maximum amount of sunlight. Spraying the sheds with a solution of five per cent. lysol and dusting with lime occasionally helps materially in keeping the calves free from disease. Where calves are tethered on pasture they should be moved frequently, and where they are allowed free range a number of small paddocks should be rotationally grazed to minimise the risk of infection by fouling of the pasture.

Buildings.

Movable sheds, similar to those used for pigs, may be recommended also for calves. The position of these houses may be altered with the seasons to render maximum protection against cold winds and rain and to make the greatest use of sunlight. In addition no particular area of pasture need be frequented by the calves to a greater extent than any other part of the paddock. The shed should be dry, free from draughts and plentifully furnished with clean bedding.

Permanent buildings, such as calf pens, should face the north in order that they may receive as much sun as possible in the winter, while retaining a certain amount of shade at the rear of the pens in the summer months.

In ideal circumstances pens are provided for each calf, but as this is rarely possible for economic reasons much may be done to ensure orderly and correct feeding by installing miniature bails. These are quite easily constructed and may be made of rough timber if desired. A trough or box should be built in front of the bail to take the bucket, and later the grain, when the quantity merits such feeding. The bails may be quite open, but the floor should be impermeable to facilitate cleaning. The situation of the bails is important and should be handy to the cow shed to prevent carrying milk an excessive distance. By bailing the calf, it receives its correct ration undisturbed, and is prevented from indulging in the common though objectionable habit of sucking other calves. The tendency is

Fig. 9.
Calf-feeding bails.

further corrected by feeding dry meal in the bucket immediately after the milk. If bails are not used it is advisable to tie the calves while they are receiving their food.

Common Ailments of Calves.

The commonest ailments of calves are those connected with the digestive system and generally caused by improper management. Scouring is a symptom of digestive disorders and usually follows the feeding of too much or too little milk, milk at inconstant temperatures, unclean milk or milk too rich in fat. Another cause of disease is damp and insanitary housing conditions.

When the calf begins to scour it is wise to remove it from contact with the other calves lest the trouble prove contagious. If the case is a mild one the next feed should comprise 50 per cent. of the normal ration of milk and 50 per cent. boiled water; in more serious cases only boiled water should be fed. Gradually reinstate the normal milk ration, but feed only boiled milk until scouring ceases. A cupful of limewater added to a reduced milk ration will frequently cure a mild attack of scours. Overfeeding may be caused by feeding milk which is too rich in fat, and the apparent remedy for this is to feed as above, and then avoid any recurrence of the trouble by diluting the subsequent milk fed to a 3.5 butterfat test. Incorrect temperatures may be avoided by more frequent use of the thermometer, and unclean milk by greater attention to general dairy hygiene.

Ear Marking, Tattooing and Castration.

These operations are most suitably performed when the calf is about two weeks old. Less pain is experienced by the animal at this age, and there is less risk of excessive bleeding and shock causing a consequent setback in growth. Suitable weather should be chosen, a mild calm day being preferable, and every care should be taken to ensure that instruments are sterile and the operation is performed with the utmost cleanliness.

Dehorning.

Considerable economic loss is occasioned from time to time by cattle suffering injury by horning. Udder troubles are often initiated either directly from this cause or indirectly by frightened cows milling around in an endeavour to escape from "boss" cows. Apart from specific injury, nervous cows will not yield their best when subjected to frequent upsets in races, yards and other confined spaces. Such conditions need not persist. Cows may readily be dehorned when fully grown, but it is easier and far less painful to the animal to prevent the horns from growing when the calf is quite young. The procedure is simple and may be carried out in the following manner:—When the calf is about seven days old clip the hair from around the horn bud and smear the surrounding skin with vaseline to protect it from the action of the caustic. Then rub the horn bud with the moistened caustic stick until it is raw but not bleeding. Caustic potash is generally used for this purpose and may be obtained from chemists in rods or sticks suitable for application. When in use they should be carefully wrapped with paper to protect the operator's fingers and after using should be placed in a wide-mouthed glass jar and corked down thoroughly to exclude the air. If this precaution is not taken the chemical will dissolve in moisture absorbed from the atmosphere.

After treatment the calf should be sheltered from possible rain for a day or two to preclude any possibility of the caustic being washed down on to the face and causing severe burns. If at any time this should occur, apply a weak solution of vinegar and water to the burns.

SUMMARY.

(1) It is to the interest of every farmer to rear his young stock for replacements rather than to buy from external sources.

(2) Under present conditions and those likely to exist for several years, the rearing of well-grown heifers constitutes a national service as well as a profitable source of income to the farmer.

(3) The raising of dairy calves is a simple matter provided that commonsense is combined with sound principles.

(4) Skim milk plus readily digestible cereals is the best substitute for whole milk.

(5) There is no entirely satisfactory milk substitute. Where skim milk is not available whole milk should be fed until the calf is able to digest substitute meals and good roughage.

(6) Sweet, unfermented whole cheese-whey has a definite place in the feeding of calves.

(7) Strict cleanliness should be observed at all times and calves should never be overfed.

(8) Good shelter is essential to the young calf. It should be kept warm and dry in the winter and have sufficient shade in the summer.

(9) There is no need to persevere with horned cattle in a commercial dairy herd. Horns may be prevented from developing and consequent injuries in the herd avoided.

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Spraying to Reduce Pre-harvest Drop of Apples.

T. C Dunne,

Horticultural Research Officer.

It has been demonstrated by trials initially in the United States and later in the Eastern States of Australia that the loss resulting from the dropping of apples prior to maturity can be considerably lessened by the use of growth-promoting substances used in the form of sprays.

One of the most effective substances for this purpose is naphthalene acetic acid. The value of this material for the purpose mentioned has been appreciated by commercial interests and preparations including this substance are now available.

With a view to testing their efficiency under local conditions preliminary trials were conducted during the 1944 harvesting season with two such preparations, viz., "Clingspray" and "Phyomone." The former is available in liquid form and the latter in tablets.

In this State the most important loss with dropping prior to picking maturity is experienced with Jonathans which in some seasons fall to a serious extent in certain districts. The main trial, therefore, was done with this variety.

However, Delicious apples also cause concern and a few trees of the variety were tested.

The tests conducted and the results obtained are given below:-

A. *Variety—Jonathan.*

1. Property of H. Rudd, Argyle. Supervised by R. Cailes, Horticultural Instructor.

Sprayed.	No. of Trees.	No. of Fruits Harvested.	No. of Fruits Dropped.	Percentage Drop.
				%
Control	No Spray	5	3,289	1,221	37·2
Clingspray	Feb. 11th	3	1,555	368	19·1
Phyomone	Feb. 11th	3	1,799	419	18·9
Clingspray ...	Feb. 11th Mar. 2nd	3	1,480	281	16·0
Phyomone ...	Feb. 11th Mar. 2nd	3	2,002	338	14·7

The above figures clearly demonstrate the effectiveness of the spraying with either compound in reducing the amount of fruit dropped. As the effect of a spray with the material is normally considered to last only about three weeks, some trees had a second treatment. This additional spray apparently did further reduce the drop but only to a small degree. Harvesting was done on March 7th shortly after the later treatment. Had harvesting been delayed it is possible that further drop may have occurred from the trees sprayed only once.

B. Variety—Delicious.

1. Property of H. Rudd, Argyle. Supervised by R. Cailes, Horticultural Instructor.

The trees used had a very light crop. The data obtained are below:—

	Sprayed.	No. of Trees.	No. of Fruits Harvested.	No. of Fruits Dropped.	Percentage Drop
					%
Control	None ...	3	640	74	10·4
Clingspray	Feb. 11th	2	472	25	5·0
Do. ...	Feb. 11th Mar. 2nd	2	531	26	4·7

Picking was done on March 14th. One spraying was beneficial, but no definite further improvement could be claimed for the additional treatment.

In this trial it was observed that a definite improvement in the red colouration of the fruit was associated with the treatment. Similar effects on colour development have been noted by United States investigators.

2. Property of S. E. Hambley, Mt. Barker. Supervised by A. Gulvin, Horticultural Instructor.

In this instance comparable trees were selected, two of which were sprayed with "Clingspray" and two used as controls. A record was taken only of the fruit dropped.

	Sprayed.	No. of Trees.	No. of Fruits Dropped.
Control	No Spray	2	272
Clingspray	March 15th	2	33

The beneficial effect of treatment is clearly shown.

3. Property of M. S. Gorman, Mt. Barker. Supervised by A. Gulvin, Horticultural Instructor.

As in the test above, comparable trees were taken.

The trees were treated with "Clingspray." Results were:—

	Sprayed.	No. of Trees.	No. of Fruits Dropped.
Control	None	2	104
Clingspray	March 15th	2	34

The benefit from treatment although not as striking as in the previous instance is again demonstrated.

Use of Materials.

Although the tests reported above were of a very limited nature, there appears to be no doubt of the effectiveness of both "Clingspray" and "Phyomone" in reducing pre-harvest drop in this State.

In districts where such dropping of fruits is likely to occur, treatment with either of the above compounds should be profitable. The cost of material works out at about fourpence per tree, allowing three gallons of spray to each tree.

It is recommended that spraying be done about three weeks before the normal harvesting time or alternatively when dropping of nearly mature fruits is first noted. A good pressure spray is needed as it is essential that, for effective control of dropping, the stalks of the fruits be wetted. For the same reason, it is obvious that thoroughness is necessary.

Any information needed by growers concerning application of sprays is readily obtained from the district horticultural officers.

Molybdenum as a Fertiliser in Western Australia.

L. J. H. Teakle, Plant Nutrition Officer.

INTRODUCTION.

Scientists interested in plant nutrition are continually searching for further elements essential to the growth of plants. It is now approximately 140 years since it was discovered by water culture methods that plants would not grow unless supplied with a number of elements including calcium, magnesium, potassium, iron, nitrogen, phosphorus and sulphur, in addition to carbon, hydrogen and oxygen obtained from the air and water. These were required in relatively large quantities and may be regarded as the major elements necessary for plant growth.

It was not until well into the present century that it was established definitely that these elements themselves were not sufficient for the growth of plants and that a number of others were also required in minute amounts. In the early experiments it seems that these were supplied as impurities in the salts used in the preparation of the culture solutions. Refinement of the chemicals used in this work eliminated these impurities and led to their discovery as important factors in the mineral requirements of plants. Of these, copper has had spectacular effects on pastures and crops on a variety of Western Australian soils. Manganese has been very effective for wheat and oats on mallet soils in the Great Southern areas and for apples at Kendenup. Zinc has proved beneficial for citrus and has given spectacular results as a treatment for pines on many soil types in Western Australia. Boron has given evidence of a slight effect in some instances with swedes and apples. The amounts of these elements which are effective in promoting the healthy growth of plants is very small and on this account they are often called "micro-elements" or "minor elements."

Of recent years, molybdenum has been added to this list of micro-elements. In 1936 American workers showed that it was necessary for the growth of the mold *Aspergillus niger* and, a little later, that it was necessary for the fixation of nitrogen by *Azotobacter*, a free-living nitrogen-fixing micro-organism of the soil. In 1939 Californian workers discovered that it was necessary in minute amounts for higher plants. Deprived of molybdenum, the leaves of the plants were yellow and mottled and burnt on the margins. The blossoms fell off and fruit failed to set.

The first discovery of the importance of molybdenum under field conditions was made by Mr. Anderson in South Australia in 1942.* Ironstone soils in the Adelaide hills had become noted for their unsuitability for subterranean clover in spite of generous fertiliser practice. In fact, the only places where subterranean clover would grow were on ash-beds. Spectroscopic examination of ashes from the area by Mr. Oertel, of the Waite Institute, showed the presence of molybdenum as well as other elements and Mr. Anderson tested the effect of each in the field. The effect of molybdenum proved spectacular. He found that there was an increase in the growth from 2 to 3 cwts. of meadow hay per acre when

* Journal Aust. Inst. Agric. Sci. 8: 73-75, 1942.

superphosphate and micro-elements, excluding molybdenum, were applied, to nearly 27 cwts per acre when molybdenum was included in the mixture. This effect is illustrated in Figures 1 and 2, copied from Mr. Anderson's paper.

Later he discovered that even smaller quantities—as little as a few ounces of roasted molybdenite per acre—were just as effective. The result pointed to the importance of molybdenum in the field and it was tried at Cressy at Tasmania on gravelly, shaley loam where subterranean clover failed to flourish. Again the results were very satisfactory.

These results have attracted much attention throughout Australia and further tests have shown molybdenum to be deficient over considerable areas, particularly on ironstone country, in South Australia, Victoria and Tasmania.

Fig. 1
Seeded pasture receiving superphosphate only, Meadows, South Australia.
H. D. Cocks, photo.

EXPERIMENTS IN WESTERN AUSTRALIA.

In Western Australia, molybdenum had been included in mixtures in experiments carried out by officers of the Department of Agriculture and Forests Department since 1940. No growth responses had been observed under a variety of soil conditions with pasture, lupins and grape vines, but analysis in one instance showed an increase in the molybdenum content of treated lupins. Officers of the Forests Department report a temporary stimulation in growth with pines.

In view of the responses recently observed in other States, over 30 tests have been carried out by officers of the Department of Agriculture this year. In most cases subterranean clover pasture was used for the experiments on account of its value as an indicator plant. In the light of the favourable responses on ironstone gravelly soils in other States, the experiments included these types wherever possible. Tests made generally consisted of 10 chain strips, top-dressed with superphosphate—120 lbs. per acre, plus roasted molybdenite—four ounces per acre, in comparison with an adjacent strip receiving only 120 lbs. of superphosphate, applied broadcast. The roasted molybdenite contained 55 per cent. molybdenum (Mo).

The growth of the pasture on the strips was observed as often as possible during the season.

A substantial response to molybdenum was observed only on one site, that on Mr. J. J. Duggan's property, Yericoin. The season was very dry and the growth short, but during the spring the strip treated with molybdenum became increasingly superior to that receiving superphosphate only. On Mr. J. Guimetti's farm, Dardanup, there seemed to be a slight growth response to the molybdenum when observed on 10th July, 1944, and it was reported that stock appeared to prefer the molybdenum treated strip. The reported stock preference was in accordance with reports from other States. However, the effect did not persist.

There was no suggestion of any growth response to molybdenum on any other site.

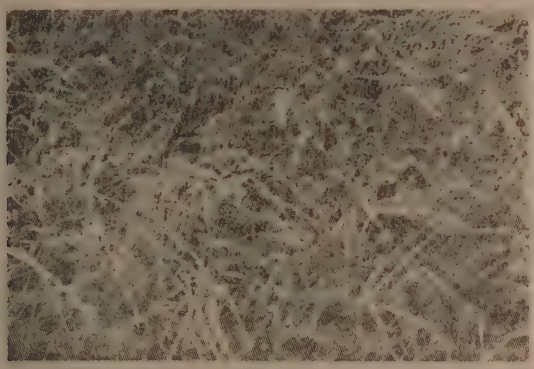

Fig. 2.
Seeded pasture receiving superphosphate and minor elements, including molybdenum. Meadows, South Australia.
H. D. Cocks, photo.

During the growing season, samples of subterranean clover leaves were taken for analysis† as it was hoped that the molybdenum content of the leaves would be a useful guide to the requirements under Western Australian conditions. The results are given in Table 1.

Stephens and Oertel‡ consider that one part per million is the normal molybdenum content of subterranean clover and white clover, as clover with 0·5 parts per million was pale in colour and responded to molybdenum treatment. Lower concentration may suggest deficiency. The figures for subterranean clover leaves and petioles in Western Australia do not support this conclusion and indicate the need for further research to determine standards under Western Australian conditions. The substantial increase in the leaf content following treatment with the molybdenum suggests that leaf analysis will be very useful in diagnosis, provided that samples are obtained at a comparable growth stage. It is suggested that a very suitable time would be at the initiation of flowering. This represents a definite physiological stage when, as a rule, there will be sufficient material to sample.

Table 2 gives information regarding the sites at which tests were made and pertinent observations.

† Using Marmoy's method as described by Piper, Soil and Plant Analysis, University of Adelaide, 1942, page 349.
‡ Journal Coun. Sci. Ind. Res. 116: 69-73, 1943.

Table 1.

MOLYBDENUM CONTENT OF SUBTERRANEAN CLOVER LEAVES AND PETIOLES FROM AREAS RECEIVING SUPERPHOSPHATE ONLY AND SUPERPHOSPHATE AND MOLYBDENUM.

Sample	Property.	Soil.	Growth Stage.	Date Sampled.	Molybdenum content of sub-clover leaves as p.p.m., air dry material.	
					Super. only.	Super. and molyb-denum.
402/3	J. J. Duggan, Yericoin*	Ironstone, gravelly sand	Leaves green to yellowing off-flowering finished	1944. Sept.	0·1	0·4
403/4	do.	Sandy and ironstone gravelly soil	do.	Sept.	0·1	0·7
3576/7	E. H. B. Lefroy, Cranmore Park	Ironstone gravelly soil	Green, early flowering	Aug.	0·7	8·9
3578/9	E. Chambers, Walebing	... ...	do.	Aug.	0·2	0·1
3580/1	do.	... ...	do.	Aug.	0·2	5·6
3582/3	V. T. Clune, New Norcia	Brown loam—York Gum country	do.	Aug.	0·5	5·0
3584/5	Stephens, Bindoon	Brown loam—grey sand with quartz gravel	do.	Aug.	0·2	2·0

* Substantial growth response was observed only on the site on Mr. J. J. Duggan's property.

Analyses by A. G. Turton, Govt. Chem. Laboratory.

DISCUSSION AND CONCLUSION.

These tests indicate that the growth response by subterranean clover on ironstone gravelly soils and other soil types to fertilisers containing molybdenum is not likely to be general in Western Australia. Of 32 sites under test for which information is available, only one showed a definite growth response. No growth effect was apparent on any other site. However, with respect to three of the five sites for which analytical data were obtained, the molybdenum content of the subterranean clover leaves must be considered low, if not in the deficiency grade. It is possible, therefore, that certain soils in the Western Australian pasture belt are sub-optimal with respect to molybdenum, and evidence of deficiency may develop in the future. The possibility of other deficiencies obscuring the molybdenum effect must not be overlooked.

Treatment with molybdenum fertilisers generally effected a substantial increase in the molybdenum content of the subterranean clover. No explanation can be offered for the single anomalous case in Table 1.

In spite of the general failure to obtain growth responses under Western Australian conditions, the results of this year's work point to the need for further investigation of the molybdenum status of Western Australian soils, especially with respect to the production of subterranean clover. The spectacular results reported from the Eastern States cannot be expected in Western Australia.

TABLE 2.

TESTS WITH MOLYBDENUM AS A FERTILISER FOR PASTURE—GENERALLY SUBTERRANEAN CLOVER.

Molybdenum applied as Roasted Molybdenite (55 per cent. Mo), 4oz. per acre, with Superphosphate (18 per cent. P_2O_5), 120 lbs. per acre. Control—Superphosphate 120 lbs. per acre.

Farmer.	District.	Range of Soils Covered by Test Strips.	Response to Superphosphate.	Observed response to Molybdenum.
Ward, H. T.	Namban	Ironstone gravelly ; sandy	Not obvious	Not obvious.
Lefroy, E. H. B.	Lyon's Camp	Ironstone gravelly	Very marked	None.
Chambers, E.	Walebing, Moora	Ironstone gravelly ; sandy	do.	Possibly slight response August ; none end of September.
Duggan, J. J.	Yericoin	Ironstone gravelly ; sandy and gravelly	do.	Marked response in amount of growth, no colour response obvious.
Clune, V. T.	New Norcia	Brown sandy loam—York gum country along Moore River	Not obvious	None.
Stephens Bros.	Bindoon	Red loam ; ironstone gravelly, etc.	Marked	do.
Wongan Hills Research Station	Wongan Hills	Sandy and ironstone gravelly	do.	do.
Merredin Research Station	Merredin . .	Sandplain	do. . . .	do.
Narrogin School of Agriculture	Narrogin	Not reported	Not reported	do.
Struthers-Smith	Kojonup	Ironstone gravelly	do.	do.
Kahan, R. R.	do.	Ironstone gravelly ; sandy	Not obvious	Not obvious.
Lewis, M.	Quinwindup	Ironstone gravelly ridge	Not reported	None.
Guimelli, J.	Dardanup	Ironstone gravelly ; sandy loam ; loam	Not reported	Slight, and apparent preference by stock in July ; none in spring.
Mitchell, G. V.	Donnybrook	Ironstone gravelly	do.	None.
Beckett, K. G.	Metricup	do. do.	do.	do.
Walker, R.	Witchcliffe	Sandy and sandy loam	Very marked	do.
Wright, E. E.	do.	Not reported	Not reported	do.
Nilsson, J. A.	Margaret River	do.	do.	do.
Abel & Co.	Boyup Brook	Ironstone gravelly	Not reported	do.
Farleigh, E.	do.	do. do.	Very marked	do.
Forrest, P. D.	do.	Ironstone gravelly, etc.	Marked	do.
Jay, H. F.	Yanmah, via Manjimup	Ironstone gravelly	Not reported	do.
Javens, H. P.	Middlesex, via Manjimup	Ironstone gravelly types	do.	do.
Humphreys, M. A.	Quinninup, via Manjimup	Ironstone gravelly loam —Karri	Marked	do.
Button, C. H.	Carbarup, Mt. Barker	Ironstone gravelly types	Not obvious	Not obvious.
Pardelup Prison Farm	Mt. Barker	Ironstone gravelly ; sandy loam	do.	do.
Norton, E. R.	Narrikup	Sandy with clay subsoil ; ironstone outcrops	None	None.
Norton, J. G.	Chorkerup	Ironstone gravelly	Not obvious	do.
Henning, McA.	Albany	Sand on ironstone gravelly hard pan	do. (Drooping flo	Not obvious. wered clover.)
Norman & Sons .	Many Peaks, Albany	(1) Ironstone gravelly soil	Not reported	None.
Do. do.	do. do.	(2) Not reported	do.	do.
Denmark Research Station	Denmark	Sandy and ironstone gravelly soil	do.	do.

Feeding Stuffs.

G. K. Baron Hay, Under Secretary for Agriculture.

The control of bran and pollard under the National Security Regulations has been in operation since early this year and is based on the pegging of the distribution of bran and pollard as it was in the six months July to December, 1943. This control and rationing was necessitated by the greatly increased demand for mill offal becoming greater than the supplies available. Flour mills have been working practically to capacity for some 18 months so that no significant increase in supplies of bran and pollard is possible. It is the object of the Department of Agriculture to distribute the available supplies as equitably as possible and to ensure that farmers obtain a share of the supplies, but realising fully that requirements cannot be met in full and that all must share in the shortage.

It is the desire of the department to obtain this result without introducing a system of licenses and permits with all its attendant clerical work for the produce merchant, the miller and the Department.

Under the present system each buyer is allotted a quota, the quota being his purchases during the six months July-December, 1943, and while mill production is maintained at its present level all buyers should be receiving a high proportion of their quota. Quotas may not be completely filled because the Department of Agriculture makes provision for new consumers, those who were not purchasers of bran and pollard in the basal six months.

Millers and produce merchants have been instructed not to supply new customers except on the authority of the Department of Agriculture and all new consumers should apply to the department for such authority and supply details of the numbers of stock and/or birds to be fed. Since no extra bran and pollard are available, new consumers can be catered for only by reducing the amounts distributed to other buyers—that is sales to former consumers become less than quotas.

Mills have also been instructed to sell only 90 per cent. of production until the reserved 10 per cent. has accumulated to two or three days' mill production and then to sell all production. This reserve is not static but is labile and is in constant use to smooth out irregularities of production due to stoppages in the mills or when for any reason mill production temporarily falls below maximum.

Any complaints as to unfair distribution of mill offal under this scheme will be investigated by the Department of Agriculture but complaints should be supported by details of the receivals of bran and pollard from each supplier for each month since and including July, 1943. From this data the quota can be ascertained and also whether the purchaser is receiving now a high proportion of his quota.

The following information regarding substitute stock foods has been prepared by the Animal Nutrition Officer (Dr. E. J. Underwood), the Superintendent of Dairying (Mr. M. Cullity) and the Poultry Adviser (Mr. E. Lovegrove).

"The present shortage of bran and pollard once again raises the question of possible substitute feeds, that is of feeds which will enable the producer to reduce his consumption of bran and pollard and at the same time maintain production. The only substitute feeds available in quantity at the present time—and it is unlikely that the position will be much different for many months—are gristed wheat, 'branato,' and 'pollato.' Poultry and dairy farmers are particularly concerned because of the traditional use of a high proportion of either bran or pollard or both in the rations of poultry and milking cows. These feeds are not universally used in the ration of pigs.

"In the feeding of poultry the difficulty comes mainly through the shortage of bran, because of the light and bulky nature of this feed. Pollard cannot be considered essential in poultry mashes. Recent experiments carried out at Werribee, Victoria, have shown that 'ground wheat can be used with advantage to replace pollard' in a poultry mash. At Muresk Agricultural College mashes without pollard have been used successfully and shown themselves capable of sustaining high egg yields. The 'wet mash' used was made up as follows:—Bran, 5 parts; wheatmeal, 3 parts; oilcake, $\frac{1}{2}$ part (damp measure); meatmeal, $\frac{1}{2}$ part; bonemeal, $\frac{1}{4}$ part. The dry mash used was 5 bran, 3 wheat, plus the protein supplement.

"To replace part of the bran in poultry mashes 'branato'—which has many of the physical and nutritive properties of bran—can be used. Where oats or barley are available to poultry farmers, these cereals ground finely are effective substitutes for bran because of their more fibrous nature compared with wheat. Neither oats nor barley, however, are available in sufficient quantities for them to be generally used. A further improvement of rations low in bran can be effected by raising the proportion of chopped greenstuff, wherever this is possible, from the present common ration of 50:50 by volume of mash and greenstuff to 40:60. The overall fibre intake of the birds will not be raised too high by this means and the protein intake slightly improved, since average greenstuff contains about 30 per cent. protein on the dry basis compared with 13 per cent. in bran.

"In the feeding of dairy cows, crushed wheat is proving a valuable feed well fitted to take the place of other feeds in short supply. Recent experience in this State and in Victoria has shown that—where wheat is introduced gradually into the concentrate ration—it can be considered a 'safe' and cheap foodstuff for milking cows. As much as 8 lbs. per day of crushed wheat has been fed to high producing cows in this State and up to 12 lbs. in Victoria without harmful results. It, however, is advisable not to use wheat as more than 50 per cent. of the concentrates fed and to add 1-2 per cent. ground limestone. The slightly lower protein content of average wheat compared with average bran and pollard makes it advisable to use a small proportion of a protein concentrate with the grain. The value of crushed wheat compared with bran, pollard and oats is given in the table below. The cheapness of wheat compared with bran and oats as a concentrate is clearly shown by this table.

Feed.	Price per short ton (Perth).	Price per 100 lbs.	Food Units (Energy) per 100 lbs.	Price per Food Unit.
	£ s. d.	s. d.		s. d.
Crushed Wheat	7 5 0	7 3	72	1 2
Bran	6 5 0	6 3	44	1 7
Pollard	6 5 0	6 3	69	1 1
Feed Oats	9 3 0 (3s. 8d. per bushel)	9 2	62	1 9

"In conclusion it should be stated that it is not suggested that crushed wheat or 'branato' or 'pollato' should entirely displace bran and pollard from poultry and dairy cow rations, or to claim that they are equally satisfactory in all respects. The present shortage of bran and pollard, however, makes it essential that they should be used to eke out supplies of these feeds. There is ample evidence that this can be done safely and economically."

Copper Deficiency in the Busselton-Augusta District.

A REVIEW OF ITS HISTORY AND INVESTIGATION WITH SPECIAL REFERENCE TO THE RE-ESTABLISHMENT OF SUBTERRANEAN CLOVER.

L. T. Jones and H. G. Elliott.

SUMMARY.

It is now known that the crop, stock, and pasture problems that baffled early investigators in these areas were due to a copper deficiency in the soil. It has been shown that in the Busselton-Augusta district, where copper deficiency has proved to be widespread, the use of bluestone (or its equivalent in other sources of copper-containing material) on copper deficient land, usually at the rate of 10 lbs. per acre, has produced the following beneficial results:—

1. Following reseeding, there has generally been a quick regeneration of subterranean clover on previously "stalled" areas.
2. There has been an increase in the copper content of the pasture, which has been followed by improved health and production of the stock grazing on these treated areas.
3. There has been an increase in the carrying capacity of these "stalled" areas.

As a general rule, one application of 10 lbs. of bluestone per acre appears to be effective for at least four years. The benefits resulting from the re-establishment of subterranean clover on these previously stalled areas represents a return to the farmer that far outweighs the extra cost of the bluestone, and the subterranean clover seed where required.

Other copper-containing substances have been used as fertilisers on copper deficient land and, when used in amounts to supply the same amount of copper, have proved equally as effective as bluestone. Oxidised copper ore from the mining areas, roaster residues from the fertiliser manufacturers' dumps and cinders from a Melbourne furnace were subjected to these tests.

INTRODUCTION.

The purpose and scope of this article is to give a general outline of the early history of the problem and to show by quoting field observations, farmers' reports, and experimental results, that where a copper deficiency exists, the use of small dressings of copper containing materials results usually in the regeneration of healthy and vigorous subterranean clover, increased carrying capacity, and an improvement in the health and production of the stock.

However, the farmer should bear in mind that the application of bluestone and other copper-containing materials *will only remedy a copper deficiency in the soil* and not replace superphosphate nor solve problems due to other causes. Among the other possible factors contributing to the absence of poor growth of subterranean clover in a pasture are insufficient or excess moisture, competition from other plants, inadequate fertiliser application, improper pasture management, a poor seed bed or insufficient viable seed for good germination.

EARLY HISTORY OF THE PROBLEM.

As early as 1928 officials of the Group Settlement Department were concerned because oat crops and pastures on the red sandy soils near Vasse were not satisfactory despite generous applications of superphosphate. Reports at this stage indicate that the Group Settlement Department was conducting trials with fertilisers and pasture species. But although a variety of fertiliser treatments containing nitrogen, phosphate and potash were tried, farmyard manure was the only treatment giving reasonably good subterranean clover growth.

It is interesting to note that at this stage one of the introduced pasture species—drooping flowered clover—recommended for moist land, was reported to be showing promise in these problem areas. In the light of later experience it is now known that its success was due to its tolerance of a lower copper content

Fig. 1.

The effect of minor-element mixture applied in 1937 and 1938. Left: minor element mixture and superphosphate bring about regeneration of subterranean clover. Right: silver and brome grasses dominant where superphosphate only used. From the experiment on the property of G. S. Blaikie, Cowaramup. Taken October 13, 1940.

Photo, L. J. H. Teakle.

in the soil. Yorkshire fog and Lotus major are plants that also have a low copper requirement and grow well, particularly under moist conditions, in these districts.

There were at this time certain holdings in the Busselton district which, even after seeding and re-seeding to subterranean clover, grew only silver grass and flatweed. It was deemed economically unsound to develop these areas until the problems were solved, and in 1929 the Department of Agriculture was approached to investigate the problem of the "Red Soils of Busselton."

EARLY MINOR ELEMENT INVESTIGATIONS.

About this time the importance of minor elements in the field of plant nutrition was just being more fully realised. Presumably because of the benefit obtained with farmyard manure and the lack of response with artificial fertilisers, minor elements were considered a promising possibility as a solution to the problem.

As a result, in 1930, a pot experiment and field trials were conducted by the Department of Agriculture on the red soils of Busselton, in which a treatment was included containing the then known important minor elements.

In the field experiment, oats was sown and the treatments consisted of the usual variation of nitrogen, phosphate and potash plus the minor elements boron,

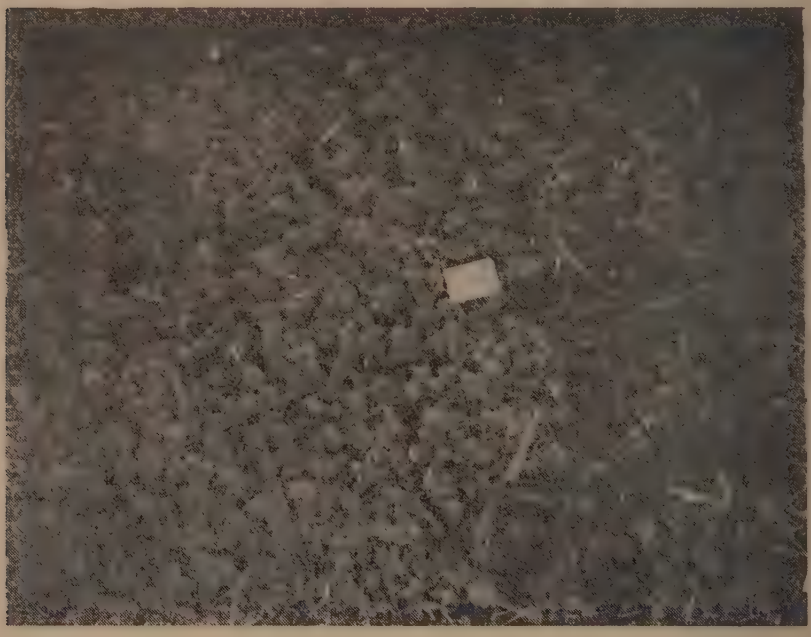

Fig. 2.

A "close up" of part of strip in fig. 1, showing the regenerated subterranean clover resulting from minor element treatment in 1937 and 1938.

Photo. L. J. H. Teakle.

manganese and iron. Unfortunately copper was not included in the list of minor elements applied with the result that no treatment showed promise of practical results.

The list of minor elements was extended in the pot experiment to include in addition copper, magnesium, zinc., etc. The effect of these treatments on the growth of oats and subterranean clover was tested and again the results proved inconclusive. The difficulties of attempting pot experiments in the open without a glass house or other suitable shelter led to the abandonment of this line of attack.

It was unfortunate that in the field trials, bluestone was omitted from the list of minor element compounds applied and that the pot experiment, under these conditions, did not give satisfactory growth. As a result the problem was still no further towards solution even after what is now known was a sound line of attack.

At the end of 1931 a concise summary of the progress of the investigations to that date shows that farmyard manure at 20 tons per acre gave the best establishment of subterranean clover and that drooping flowered clover was the only plant giving any prospect of success under normal farming practice.

Owing to urgent needs for information regarding the soils of districts proposed for settlement and in districts where settlers were faced with apparent soil problems these experiments were discontinued for some years.

THE SECOND ATTACK ON THE PROBLEM.

In 1936 it was possible to resume the field experiments with special fertilisers on a small scale. The discovery of R. V. Allison and others that the importance of heavy dressings of stable manure on the Everglades in Florida was due to the copper, manganese and zinc supplied threw new light on the problem and the response of unthrifty pines to zinc at Ludlow, some 20 miles distant, seemed suggestive. However, zinc sprays, so effective with pines, did not benefit pastures.

Two experiments were laid down in 1937 with the object of determining the necessity of certain minor elements in pasture production. The two sites selected for the experiments were on the properties of P. Moylan, Vasse (typical of the "red soils of Busselton") and G. S. Blaikie, Cowaramup.

The experimental treatments consisted of the usual variations of nitrogen, phosphate and potash plus in addition a minor element mixture similar to that used in the pot experiment in 1930, but the ingredients were applied at the rate of 20 lbs. per acre each. The fertilisers were applied as top-dressings on the existing pasture and no effort was made to reseed the area with special species.

No significant effects were observed in the first year except evidence of damage from borax applied at the rate of 20 lbs. per acre. In the second year boron was eliminated from some treatments and in subsequent years the plots received superphosphate only.

Bluestone was included in these treatments but no response has yet been observed on this early experiment on P. Moylan's property. A later experiment in the same paddock, in 1941, when the experimental area was sown with subterranean clover, gave a good response to copper-containing fertilisers in the first year. The 1937 treatments were applied to the existing pasture and it is now evident that the lack of response was most probably due to the experimental area not being re-seeded with subterranean clover. The existing pasture at P. Moylan's property consisted of pasture species that were tolerant of a low copper content in the soil by virtue of their survival, and did not therefore benefit from a dressing of bluestone.

Even in the first year on G. S. Blaikie's experiment some subterranean clover was present but it was not till the third year (1939) that Mr. Blaikie observed a slight improvement on the four plots that had received minor element mixture. These four plots were outstanding in the fourth year (1940) owing to the vigorous regeneration of subterranean clover. Apparently it had taken four years for sufficient natural reseeding to occur to produce a satisfactory stand of subterranean clover.

Owing to the lack of response of pastures to zinc, the discovery of copper deficiency with stock, and the results of collateral experiments laid down in 1939, it was presumed that the effect was most likely due to the copper in the minor element mixture.

COLLATERAL INVESTIGATIONS.

From 1936, when renewed interest was taken in the pasture problems of this area, until the end of 1938, the problem of the deterioration of subterranean clover pastures was also being attacked from the aspect of cultivation practices.

It was the opinion of many people at the time that these areas were suffering from "clover sickness." They argued that the succession of good subterranean clover pastures obtained in the early years of establishment, had resulted in a

Fig. 3.

Right: The effect of bluestone, at the rate of 15 lbs. per acre, applied in 1939, on the regeneration of subterranean clover. Left: Note the dominance of silver grass and brome grass where no copper was applied. From the experiments on the property of A. Millar, Forest Grove. Taken October 12, 1940.

Photo, L. J. H. Teakle.

high nitrogen content in the soil, which favoured grasses and weeds in competition with clovers. Farmers were recommended to scarify the affected areas and sow oats to absorb the excess nitrogen, but it was observed that as a rule the oats did not flourish and the practice did not increase the subterranean clover content of the pasture. Previously good subterranean clover pastures had been replaced by good stands of drooping flowered clover and, in many cases, where this occurred, deaths of stock from what was known as "falling disease" were being reported.

At the end of 1938 the research workers concerned with the investigation of "falling disease" in cattle, which was prevalent in the same areas as the "stalling" of subterranean clover, suggested that "falling disease" was due to a copper deficiency. This conclusion was shortly afterwards fully confirmed by further experimental evidence. Also, in 1938, responses to copper were obtained with potatoes, other vegetables, and pastures in the Albany district.

In the light of such accumulated evidence, the stage was now set for a new attack along the lines of minor-element treatments using sown crops and pastures as indicators.

THE FIRST DEFINITE RESPONSES TO COPPER WITH CROPS AND PASTURES IN THESE AREAS.

In 1939 an experiment was laid down on the property of Mr. A. Millar,

Fig. 4

A "close-up of part of strip in fig. 3, showing the regeneration of subterranean clover as a result of a bluestone application. Left: Superphosphate only. Right: Superphosphate and bluestone.

Photo. L. J. H. Teakle.

Forest Grove, designed to test the effect of various fertilisers, cultural treatment, and minor-elements (copper, manganese and zinc) on the regeneration of subterranean clover. At the same time an experiment was conducted on the property of Mrs. E. A. Smith, Bramley, using similar fertiliser and minor-element treatments on sown oats and subterranean clover. At the end of the first year the results were inconclusive but observations during the second year (1940) on both properties indicated clearly that where bluestone dressings had been made, excellent stands of subterranean clover were obtained.

The properties of A. E. Russell, Cowaramup, and F. Wilkinson, Metricup, were selected in the same year (1939) for an oat fertiliser and minor element experiment because both properties were affected with "falling disease" and subterranean clover had "stalled" being replaced to a large extent by drooping flowered clover, Lotus major and annual grasses. Oats and subterranean clover for re-establishment were sown as the indicator plants. The result of these trials was that it was concluded that the indications were that superphosphate plus bluestone give higher yields of oats and subterranean clover and that manganese appeared to give some response. Zinc sulphate, at the rate of 5 lbs. per acre, appeared to reduce yields.

At the suggestion of a Departmental Officer, Messrs. Coley Bros., at Marybrook in 1938, used bluestone at the rate of 10 lbs. per acre, with potatoes on certain lands, but no benefit was apparent. In 1939 subterranean clover established and showed excellent growth on the lands treated with bluestone in the previous year. Further trials were conducted on this property in 1940 and responses to copper were obtained with oats and barley.

As a result of these trials and the collateral evidence of the Falling Disease investigations, many farmers considered that bluestone warranted a trial and, as early as 1940, applied bluestone to their pasture, often with amazing results. Today, of course, bluestone is used enthusiastically by farmers and it needs no salesmanship to convince them of the benefits of bluestone on copper deficient soil.

THE 1940 TRIALS.

Following on the leads given by the previous year's work, two oat and barley variety trials were conducted, but across all varieties, strips of bluestone, manganese sulphate, and roaster residues, alone and in combination, were applied in addition to the normal superphosphate dressing. These trials were on the properties of Messrs. Coley Bros., Marybrook, and Bacon, "Radford Park," Vasse. At Marybrook all copper treatments produced good yields of either oats or barley and where copper was omitted crop failures resulted, The trial on the property known as "Radford Park" was a failure as far as the oats and barley were concerned, the land being water-logged in the winter months. However, there was sufficient evidence to show that all copper-containing treatments gave far superior regeneration of subterranean clover.

The area selected for the trial at Radford Park was originally sown down to subterranean clover about 1925. The clover persisted until 1932 when it was replaced by drooping flowered clover and subsequently the whole area was covered by weeds such as silver grass, flatweed and barley grass. The area was renovated in 1938 and sown back to subterranean clover, which failed.

Also, in the same year, five exploratory trials were carried out in the Manjimup, Northcliffe and Walpole districts to test the effects of copper, using oats as an indicator crop with subterranean clover sown for re-establishment. In these trials, various sources of copper were tested, namely bluestone, roaster residues and copper ore.

Inspections during the first season gave no indication of any results from copper applications on these exploratory trials. In the following year, the trial on the property of J. Steele, Walpole, gave definite indications of a response to copper applications. The copper treated plots, in this instance, were showing

excellent stands of vigorous subterranean clover, whereas the non-copper treated plots were showing only annual grasses, sorrel and flatweed. The experiments at Northcliffe and Manjimup did not show any definite and clear-cut responses.

Later experience in the Northcliffe district indicates a benefit from copper applications in many cases, Evidence regarding responses of pasture to copper applications in the Manjimup district is still conflicting and no definite conclusions can be drawn as yet.

In 1940, in the Busselton district, five exploratory trials were laid down which showed no immediate and consistent benefit from copper applications. However, since then the farmers in this district have used bluestone extensively with great benefit to their pastures and stock.

Fig. 5.

Comparison between superphosphate plus manganese sulphate (left) and superphosphate plus bluestone (right) from the experiment with barley and oats on the property of Messrs. Coley Bros., Marybrook. Taken October 10, 1940.

Photo, L. J. H. Teakle.

FIELD OBSERVATIONS AND FARMERS' REPORTS.

In some instances, observations have been made of the effects of bluestone for as long as four years, and on copper deficient land an initial dressing of bluestone at the rate of 10 lbs, per acre has resulted in re-establishment of subterranean clover and maintenance of vigorous growth during that period. Some cases are known where top-dressing existing pastures with copperised superphosphate has produced quite good regeneration of subterranean clover. In most cases it is necessary to reseed the paddocks with subterranean clover and if this is done, surface scarification is strongly recommended.

Many farmers on whose holdings cattle previously were in an unthrifty condition and low producers, now report that the general health of the herds has increased remarkably in a few years. Numerous farmers report increases in the carrying capacity of their farms of from 30 to 100 per cent. As is now well-known, the application of bluestone to the pasture prevents the occurrence of "falling disease" amongst dairy cows by raising the copper content of the herbage.

Not only has the re-establishment of subterranean clover been made possible by the use of copperised superphosphate, but many crops, notably oats, have given greatly increased yields following its use.

It has been observed that copper treatment has a marked effect on the appearance and vigour of subterranean clover. Treated subterranean clover is dark green and vigorous while untreated clover is often pale in colour, unthrifty and lacking in vigour. Treated subterranean clover will often remain green two or three weeks after adjacent untreated subterranean clover has wilted. Copper treated clover comes away comparatively early and vigorously, which not only extends the growing period, but permits the grazing of the pasture earlier in the season. A notable improvement is the quality and quantity of the burr and seed produced. Copper treatment on deficient areas has resulted in subterranean clover being comparatively more drought resistant and will stand a dry spell better.

Experience has shown that, following the application of bluestone, even though a stimulation of the subterranean clover may occur in the first year, it is generally not till the second year that the subterranean clover becomes properly re-established.

Many instances could be quoted of the benefit derived from bluestone applications on particular farms, but space only permits the recording of the full history of one striking case.

Mr. E. E. Wright, in 1939, took up a property at Witchcliffe which had been neglected and had received no top-dressing for at least five years. In an endeavour to stimulate pasture production he applied two bags of superphosphate per acre (one in autumn and one in spring) with most disheartening results. Good stock, which had been brought from sound country, rapidly fell off in condition and consequently in production.

In 1940, 5 lbs. of bluestone per acre was applied without the addition of superphosphate and promising results were noticed during that year. In 1941, 5 lbs. of bluestone plus one bag of superphosphate per acre was applied in the autumn. The increased growth and extent of the subterranean clover at the end of this year was remarkable. In 1942, the same rates of application were maintained and recent examinations of these paddocks showed a complete cover of subterranean clover over all paddocks. Rye grasses and cocksfoot were seen at this stage to be making rapid and vigorous growth in conjunction with the clover.

In the first two years this property barely supported 20 milking cows on a hundred acres of pasture, while at the present time 40 milking cows are well supported by this same hundred acres. This increase in carrying capacity of 100 per cent. is no doubt due to the replacement of inferior pasture species by subterranean clover, plus the better quality of the feed produced, following the applications of bluestone.

From a general point of view, one of the most encouraging aspects of these responses to bluestone is the farmers' change in outlook. He now feels that the decline in carrying capacity of his farm has been arrested and that money spent on fertilising and seeding his paddocks will give a profitable return. It is evident from discussions with farmers that, due to the use of bluestone, they no longer consider the establishment of subterranean clover a problem and their minds are now turning towards the development of their holdings, improving their herds, introducing better types of grasses, and improved methods of pasture management.

THE 1941-1943 EXPERIMENTS.

The results obtained by the end of 1940 proved the importance of copper containing fertilisers in the district. On the practical side, a number of questions were apparent:

1. What is the optimum rate of application of copper?
2. Can other forms of copper replace bluestone?
3. Is it necessary to apply copper every year as with superphosphate?
4. If so, how much should be added?

In the first place, it must be remembered that minute amounts of copper are adequate for the healthy growth of plants and animals. In subterranean clover pasture, 10 lbs. of copper in every million pounds of dry matter may be regarded as reasonably high under normal circumstances. This is equivalent to 1-3rd of an ounce of copper or 1 1-3rd of an ounce of bluestone per ton of dry matter. Thus, if the pasture yields three tons of dry matter per acre during the year, the annual drain, if all were removed, would only be one-quarter of a pound of bluestone. If this area were grazed the bulk of this copper would probably be returned to the soil in the dung and urine.

In the second place, copper is not leached from the soil by the rains to any important degree. Actually, ordinary soils rapidly absorb copper and hold it in a form highly insoluble in water. In fact, some soils hold the copper so firmly that plants are unable to make use of it until dressings of 1 cwt. of bluestone per acre have been made. Fortunately bluestone applied to the Busselton and Margaret River soils does not appear to be absorbed so tenaciously and small amounts of bluestone are adequate to benefit the crop.

In 1941, ten experiments were laid down on seven known copper deficient farms to gather further accurate information on the effect of copper fertilisers on the re-establishment of subterranean clover.

Selection of Sites.

The experiments were laid down on farms, in the Margaret River and Busselton districts, that were known to be copper deficient. To fully understand the significance of the results, it must be borne in mind that before the use of copper on these farms the pasture had definitely "stalled."

In some cases subterranean clover has been replaced by drooping flowered clover, other minor clovers, Yorkshire fog, or Lotus major.

With respect to drooping flowered clover, in some cases it established itself naturally, while in other cases it was sown intentionally in past years on moist areas that were considered too wet and sandy for subterranean clover.

In other cases, the pasture had deteriorated still further and only silver grass, spear grass and flatweed survived. The position is now that the no-copper plots in the experimental paddocks are practically the only areas on these farms that have not been topdressed with copper-containing fertilisers.

Materials used in these Trials.

The copper-containing materials used in these experiments were:—Bluestone (25 per cent. copper), copper ore (17 per cent. copper), roaster residues (2.5 per cent. copper) and Melbourne Cinders (1 per cent. copper). All these materials, except bluestone (copper sulphate), are liable to vary in composition between different samples.

Bluestone is a commercial preparation, oxidised copper ore comes from the mining areas, roaster residues is from the fertiliser manufacturers' dumps, while Melbourne Cinders were obtained from a Melbourne furnace.

Aim of the Experiments.

The aim of the experiments was to gather information on the effect of rates, sources and frequency of application of copper-containing fertilisers on the regeneration of subterranean clover. Three types of experiments were used, namely:—

1. *A comparison between bluestone, other sources of copper, and bluestone plus five other minor elements.*—This set of experiments was located on the two following sites:—

D. Bell, Carbunup, Vasse.

P. Moylan, Kaloorup, Vasse

Conclusions:

(1) Copper-containing fertilisers have made possible a striking regeneration of subterranean clover

(2) All sources of copper were equally effective.

(3) The minor elements used in addition to bluestone had no observable benefit.

2. *A comparison between four different sources of copper at various rates (equivalent to 5 to 20 lbs. of bluestone).*—The four experimental sites were located on the following properties:—

(a) G. S. Blaikie, Cowaramup.

(b) Mrs. A. Millar, Forest Grove.

(c) F. Bywaters, "Radford Park," Vasse.

(d) F. Wilkinson, Metricup.

Conclusions:

(1) At three properties copper-containing fertilisers gave good regeneration of subterranean clover. At the fourth property (Blaikie) no response to copper was observed by the end of the third year.

(2) Five pounds of bluestone per acre (or its equivalent in other copper-containing materials) is equally effective for subterranean clover regeneration as 20 lbs. of bluestone (or its equivalent in other sources of copper) for at least three years after the original application.

Summary of Results from Sources and Rates of Copper Experiments.

Because all rates and sources of copper were equally effective in the regeneration of subterranean clover, the results of these above six experiments can be simplified into a table giving the average percentage of subterranean clover in the pasture as a comparison between copper treated plots and untreated plots during the three years that the experiments have been conducted. See table 1.

TABLE 1.

THE INCREASE IN SUBTERRANEAN CLOVER DUE TO COPPER APPLICATIONS.

Copper applied in the first year of establishment only at rates equivalent to 5 to 20 lbs. of Bluestone per acre.

Location of Experiments.	Percentage of Subterranean Clover in the Pasture.					
	No Copper Applied.			Copper Applied.		
	1941.	1942.	1943.	1941.	1942.	1943.
	%	%	%	%	%	%
D. Bell, Vasse	25	10	15	75	80	55
P. Moylan, Vasse	15	15	10	40	85	85
A. Millar, Forest Grove	*Nil*	10	10	5	35	65
F. Bywaters, Vasse	25	50	85	60	85	95
F. Wilkinson, Metricup	35	70	75	50	80	85
G. Blaikie, Cowaramup*	20	20	Trace	20	25	10

* Site at which regeneration failed to occur.

Method of Assessment of Subterranean Clover Percentages.

Under the circumstances it was impossible to undertake any more detailed method of recording the increase in subterranean clover than by visual estimation of the mower cuts made on each plot in connection with hay yields. The percentage figures obtained are comparative and are considered to be sufficiently accurate as to give a true representation of the relative subterranean clover content of the pasture in each treatment.

3. *Will annual applications of bluestone improve the re-establishment of subterranean clover?*—Experiments to gain information on this question were laid down on the following properties:—

(a) Mrs. A. E. Smith, Bramley.

(b) Mrs. A. Millar, Forest Grove.

(c) F. Bywaters, "Radford Park," Vasse.

(d) F. Wilkinson, Metricup.

Conclusions:

These four experiments showed that when 10 lb. of bluestone per acre was applied in the first year, additions of up to 10 lb. of bluestone annually in the two succeeding years had no better effect on the re-establishment of subterranean clover.

The results of these four experiments are given in table 2 in the form of the average percentage of subterranean clover in the pasture on the four plots receiving the same treatment.

TABLE 2.

RESIDUAL EFFECT OF BLUESTONE EXPERIMENTS.

Bluestone Applications in Succeeding Years.—Their effect on the Re-establishment of Subterranean Clover.

	Bluestone Application in lbs. per acre.			A. Smith, Bramley.			A. Millar, Forest Grove.			F. Bywaters, Vasse.			F. Wilkinson, Metricup.		
	1941.	1942.	1943.	1941.	1942.	1943.	1941.	1942.	1943.	1941.	1942.	1943.	1941.	1942.	1943.
				Percentage of Subterranean Clover in the Pasture.											
A	10	*nil*	*nil*	20	55	40	5	50	n.d.	30	75	n.d.	40	70	55
B	10	2½	2½	15	70	50	10	50	n.d.	35	75	n.d.	45	70	60
C	10	5	5	30	40	25	5	70	n.d.	55	95	n.d.	45	75	50
D	10	10	10	20	75	40	10	50	n.d.	40	70	n.d.	40	70	70
E	*nil*	10	*nil*	15	50	40	0	0*	n.d.	10	40	n.d.	15	65	60
F	*nil*	10	2½	10	30	5	0	0	n.d.	5	50	n.d.	30	80	75
G	*nil*	10	5	10	45	35	0	0	n.d.	10	35	n.d.	25	80	50
H	*nil*	10	10	15	30	25	0	0	n.d.	5	40	n.d.	20	65	70
J	*nil*	*nil*	10	25	25	5	0	0	n.d.	5	50	n.d.	40	45	45
K	*nil*	*nil*	10	15	30	25	0	0	n.d.	5	30	n.d.	15	40	55
L	*nil*	*nil*	10	15	15	15	0	0	n.d.	0	5	n.d.	15	50	40
M	*nil*	*nil*	10	10	30	25	0	0	n.d.	0	25	n.d.	15	25	40

* A. Millar's experiment—superphosphate top-dressing only in 1942, and therefore bluestone applications planned for 1942 were applied in 1943.
n.d. (not determined)—areas grazed too long and no hay obtained.

Discussion of Experimental Results.

1. *Rapidity of Regeneration of Subterranean Clover.*—Some properties gave good regeneration in the first year, others in the second year. An experiment on Mrs. A. Millar's property did not re-establish well until the third year, but a poor initial seed bed may have contributed to this result. Increasing the rate or frequency of the copper application had no effect on the course of the subterranean clover regeneration. See table 2.

2. *The Effect of Grazing Animals.*—The results on Bywaters' and Wilkinson's properties indicate a progressive improvement of the control plots (receiving no copper) during the experiment. It is thought that this improvement is due to the spread of the effect of the copper from treated areas through the dung and urine of grazing animals. In the 1943 season it was observed on F. Bywaters' Sources and Rates of Copper Experiment that although a fortnight before hay cutting the subterranean clover on the whole paddock was uniformly good in appearance, at hay cutting time the subterranean clover on the no-copper plots appeared to be drying off more severely than the surrounding coppered plots.

3. *Decrease in Subterranean Clover in 1943 Season.*—Experiments on Bell's, Smith's and Wilkinson's properties showed that areas that had good subterranean clover stands in the 1942 season did not maintain this high subterranean clover content of the pasture at harvest time in the 1943 season.

While a number of factors may have operated, it is felt that the severely dry spring and early summer of 1943 were largely responsible. The more hardy grasses finished better than the subterranean clover which is more dependent on late rains.

General observations would support the opinion that in these cases lack of moisture is a major contributing factor to this decline. Where better moisture relations occurred through seepage, less droughty soil types, or even simply as the result of some shading from the hot sun, no decline in subterranean clover content was noticed.

Whatever the real cause, it is evident that additional dressings of bluestone will not correct the trouble.

4. *No Response on a Reputed Copper Deficient Area.*—The experiment on G. S. Blaikie's property presents the anomaly of no response to coppper-containing fertilisers on a reputed copper deficient area. The greater part of this experiment is laid out on a moist flat that is liable to waterlogging in the winter. If conditions are unsuitable for subterranean clover growth this fact would tend to mask any possible responses to copper-containing fertilisers.

It is now a question of whether this particular type of soil takes four years to give a response, whether annual applications are necessary, or whether excessive moisture or plant competition depressed the growth of clover. It will need further study to determine the correct answer.

The Effect of Copper Treatment on Hay Yields.

An attempt was made in these ten experiments to measure the effect of copper-treatment on hay yields. Owing to the great amount of extra work and expense that would have been involved, no estimations were made of total grazing capacity but only of hay yields. The paddocks were grazed until late August and then shut up for hay production. Another complicating factor was that cows grazing on adjacent coppered areas would raise the copper content of the non-coppered plots and so interfere with a true basic comparison.

As a general rule, it was found that where subterranean clover replaced drooping flowered clover or a good stand of Yorkshire fog, Lotus major and minor clover, no significant increase in the hay yields could be demonstrated, using the relatively rough methods necessary under these circumstances. Where, however, the pasture had deteriorated still further, and with regeneration, subterranean clover replaced silver grass, spear grass and flatweed, the hay yields increased on some plots from about half a ton per acre of inferior hay up to one to two tons of good clover hay.

However, the hay yields do not summarise the position fully. The succulence, better feeding value, and longer grazing period of the increased amount of subterranean clover produced in the pasture are important factors to be considered in assessing the full value of the copper treatments. The increased carrying capacity and the improvement in milk yields and health of the stock are at present the most trustworthy indications of the benefits derived from the use of copperised superphosphate.

General Observations.

It is now becoming evident from the accumulated experience that the presence or absence of apparently healthy subterranean clover in the pasture may only be used as an indication of the probable need for copper on the more deficient areas. The possible benefit to be derived from bluestone applications to an established subterranean clover pasture will probably need to be measured by the less obvious indications, such as plant analysis, improvement in animal health, increased carrying capacity or increased production. These experiments were not designed primarily to cover these finer points but their object was mainly to measure the effect of copper-containing fertilisers on the regeneration of subterranean clover on previously stalled areas in the Busselton and Margaret River districts.

THE PROBABLE TREND OF EVENTS PRODUCING COPPER DEFICIENCY.

It is quite a reasonable question to ask why copper deficiency has occurred on these soils. There are two factors that could operate to produce this deficiency. Firstly, the soils and rocks of these areas have a low copper status originally and this fact seems to be of major importance. Secondly, the general farming practices are likely to place a drain on the already low soil reserves of copper.

Where soils are short of certain elements, such as copper, potassium, magnesium, manganese, zinc, etc., the use of superphosphate as the only fertiliser is likely to accentuate the shortage and result in deficiencies affecting the plant growth and animal health. Superphosphate supplies phosphorus, calcium and sulphur and the increased production resulting from its use places a drain on the other elements required by the plant. The grazing animal returns a large proportion of these elements to the soil, but often tends to concentrate them around the sheds and in the night paddocks. The removal of hay effects the most rapid deterioration.

In Victoria, potash deficiency has been induced by the annual cutting of hay on certain types of light land. Zinc deficiency is induced in citrus by the generous use of superphosphate under some conditions. Magnesium deficiency has arisen in New Zealand soils under similar circumstances.

In Western Australia a low phosphate status of soils is general and normal crops cannot be grown without the generous use of superphosphate. As development continues and extends, other deficiencies besides the primary deficiency of

phosphate are becoming apparent. Copper has been discussed. It is possible that potash deficiency may be the next to occur in some soil types. The Department of Agriculture is maintaining its vigilance in the investigation of the nutritional requirements of Western Australian crops and pastures and will advise farmers of revised fertiliser requirements if and when evidence is forthcoming.

INFORMATION ON THE USE OF COPPERISED SUPERPHOSPHATE.

For the convenience of farmers and to meet the conditions arising out of fertiliser rationing, two types of copperised superphosphate are at present commonly used, namely—

Mixture 1—Superphosphate containing 5 per cent. bluestone.

One part of bluestone is mixed with 19 parts of superphosphate. That is, 1 cwt. of bluestone plus 19 parts of superphosphate make up one ton of this copperised superphosphate mixture. Therefore, to apply 5 lbs. of bluestone to the acre the dressing for this mixture would be 100 lbs. per acre. This is suitable for the dairy areas under fertiliser rationing conditions.

Mixture 2—Superphosphate and oxidised copper ore.

This contains the same amount of copper as mixture 1. The addition of copper ore has proved just as effective as bluestone and is considerably cheaper. Manpower difficulties in the supply preclude its more general use.

Bluestone (copper sulphate) contains 25 per cent. of the element copper and for fertiliser purposes it is usual to apply it in the form of granulated bluestone. The crystals of granulated bluestone are about the same size as common table sugar. The present price of granulated bluestone is approximately £50 a ton. that is, £2 10s. a cwt. or roughly sixpence a pound.

Bluestone costs approximately ten times as much as superphosphate so that it can be appreciated that the indiscriminate and extensive application of bluestone should be avoided until small field trials or other evidence indicates that profitable results will be obtained from its use.

ACKNOWLEDGMENTS.

This investigation was undertaken co-operatively by the Plant Nutrition and Dairy Branches of the Department of Agriculture. Other officers taking part in the investigation and to whom acknowledgment is made are G. K. Baron Hay, L. J. H. Teakle, J. M. Nelson, A. L. Hamilton, F. E. Ryan and G. Brown.

Thanks are expressed to the farmers who made available experimental sites on their properties and assisted in the carrying out of the experiments, and also to Cuming Smith and Mt. Lyell, Farmers' Fertilisers, Ltd., for the donation of some of the fertiliser and for assistance and provision of facilities necessary for the mixing of large quantities of special fertilisers.

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Dairy Farm Targets.

In an endeavour to stimulate the production of dairy produce in Western Australia, district officers are putting into operation a plan for contacting the majority of dairy farmers with a view to the allocation of targets for the individual farms.

Although the total output of dairy produce in Australia for the year 1943/44 as compared with the five-year average prior to 1939/40 was 7 per cent. lower, the output of butter declined by 20 per cent. However, this latter decrease was off-set by increases of 60 per cent., 120 per cent., and 23 per cent. in the quantities of cheese, condensed milk and whole milk in Western Australia. The quantity of milk used for processing into butter, cheese and condensed milk is shown in the following table:—

Year.	Gallons. Butter	Cheese	Condensed Milk	Total.
1938-39 ..	30,321,666	949,985	1,207,244	32,478,905
1939-40	29,032,032	841,152	1,218,485	31,091,675
1940-41 ..	29,200,967	948,537	1,373,910	31,523,414
1941-42 ..	32,509,232	1,318,210	1,768,320	35,595,762
1942-43 ..	30,057,047	1,615,290	1,857,476	33,529,813
1943-44 ..	28,671,175	1,731,772	1,818,505	32,221,452

It will be noticed that the total output for 1943-44 was 3.6 per cent. higher than in 1939-40.

The substantial increase in the amount of cheese and condensed milk manufactured, amounting to 82 per cent. and 50 per cent. respectively, offset the small decline of 1.2 per cent. in the amount of butter.

In the current year, 1944-45, the target for production in Western Australia was set at 50 million gallons, of which 13 million gallons are required as liquid milk, leaving 37 million gallons as the requirements for manufacturing purposes. This represents an increase of 15 per cent. over the actual production of 1943-44.

In the allocation of farm targets, therefore, an over-all increase of this amount has been aimed at and it is suggested that those farmers on whom it has not been possible for the officers to call, should allocate on their own account a target equivalent to this proportionate increase over their previous year's production.

In view of the unfavourable seasonal conditions which have been experienced, it is improbable that the target will be achieved in the current year, but as targets are also being set for the following year, 1945-46, it is hoped that with improved conditions and a favourable season the total requirements will be produced.

It is interesting to examine the statistical information regarding the number of dairy cows in the State, details of which are given hereunder:—

Year	Number of Cows
1920	47,719
1925	63,008
1930	80,838
1933	116,215
1936	119,405
1939	121,852
1940	124,370
1941	128,664
1943	129,763 as at 31st March
1944	138,100 ,, ,, ,,

It will be noted that since 1939-40 there has been an increase in numbers of 13 per cent.

With the improvement in the labour and fertiliser positions, it therefore does not appear to be an impossible task for the production per cow to be maintained at the 1939 level; if this is done the target will be nearly achieved and only a small additional effort on the part of the farmer would allow complete success.

On visiting farmers, officers will discuss with them the various aspects of management, particularly feeding and the conservation of fodder, which will have an influence upon the volume of output.

The response already shown by farmers to the approach of district officers has been particularly pleasing and can best be illustrated by the following extract from the report of one officer, Dairy Instructor C. W. Tobin:—

"The production target programme being pursued by branch officers appears to me to be one of the soundest steps yet taken to increase production. The value of keeping individual farmer's records relating to total production, production per cow per acre, etc., has already been demonstrated in part of the area under my supervision and the application of this system of recording to other areas has met with an excellent response. It enables both farmer and officer to ascertain whether the best results are being obtained from each herd and property. When figures are below average it is then possible to analyse the methods of the particular farmer, and offer advice that will put him on the right track. I have yet to find a farmer who is not anxious to increase his herd production, or who is not willing to discuss means and ways of attempting an increase. Also, there are some very enlightening cases where production per cow is so low that there is tremendous room for improvement.

"I am very satisfied with the reception given to the scheme in this area. Not only has it provided me with a lot of local information, but I feel certain it has been instrumental in helping many farmers to improve their farming methods. The scheme, applied as it has been here, has revealed information that would never have been known otherwise.

Notes on Dairy Topics.

Walpole District.

Production from the Walpole district will compare very favourably with previous years despite the dry summer. Some settlers show a decrease in production while a few show a substantial increase. Increases in a year like the past one are interesting, particularly from an area where the heavy timber limits the extension of acreages. With those concerned at Walpole any increase may be attributed to judicious stocking of holdings, conservation of fodder, and the regular feeding of a supplementary ration of concentrates. It is also interesting to observe that farmers who fed a supplementary ration of concentrates right through, even when it appeared uneconomical, maintained stock in fairly good condition and when favourable seasonal conditions returned production immediately rose to a very profitable level.

Mt. Barker Area.

Progress in dairying is still being made in this area despite the adverse seasonal conditions experienced there during the past eight months. One farmer, who was running sheep, beef cattle and maintaining an orchard, last year milked four cows. In view of the urgent demand for butter production he decided to build an up-to-date milking shed and instal the necessary equipment to milk a big herd. The shed is now completed and contains a four-unit milking machine, steam boiler, steam steriliser, water laid on at convenient points and other desirable facilities. Cows are now coming into production and he proposes to milk 75 this season; 35 are already milking and on the 12th July when visited, 150 gallons of cream had been produced in the first 11 days of the month. He expects to milk 100 cows next season.

Another Mt. Barker farmer, not previously engaged in dairying, has decided to help butter production and has installed a machine on one of his properties recently used for cattle raising. He proposes to milk 50 cows this season.

Milking Machines.

Arrangements were made with the Government Statistician this year to obtain figures showing the number of milking machines in use in the State and the actual number of cows which are milked by machine. This information shows that there are 1,987 machines in use, containing 5,796 units, and on the farms where these machines are installed 76,019 cows are milked; this represents 55 per cent. of all the dairy cows in Western Australia. In 1943 information was collected regarding the number of units only, which totalled 5,006. If it is assumed that the same number of cows were milked per unit, it is calculated that 4.5 per cent. more cows were milked by machines in 1943-44 than was the case in 1942-43.

It appears, therefore, that the number of cows milked by machine increased by 10,441. The following particulars have also been obtained from information supplied by the Statistician:—

Number of units per machine, 1943-44	2.9
Increase in the number of units, 1943-44	790
Estimated increase in number of machines	263
Number of cows milked by machines	38.2
Number of cows milked per unit	13.1

The increased use of milking machines is more evident in some districts than in others. For example, in the Walpole district the work of improving conditions, etc., has been steadily continued and the position with regard to milking machines is: Twelve months ago there were six machines; six months ago, 19; today there are 25. Only six farmers are without machines and two of these are considering installing same within the next few months.

West of the Bow River, where 49 dairy farmers are located, 41 are now using machines.

The installation of milking machines has assisted in overcoming the shortage of labour and the adoption of non-stripping after milking has helped many farmers to reduce the amount of labour required in their sheds.

Hoary Cress.

(CARDARIA DRABA (*L.*) *DESV.*)

C. A. Gardner, Government Botanist,

G. R. W. Meadly, Weeds Officer.

Hoary Cress, known also as Hoary pepperwort or White weed, is a perennial plant native to the Mediterranean region and Western Asia, but which has spread as a weed to Northern Europe and Britain, as well as to other temperate countries, such as North America, New Zealand, and temperate Australia. With its comparatively recent introduction into the Merredin district, it is now recorded from Victoria, New South Wales, the Darling Downs in Queensland, Tasmania, South Australia and Western Australia. In Australia hoary cress appears to have first become established in Victoria, where today it is regarded as being the most serious weed of that State, some ninety thousand acres of land being affected. Although most serious on the wheat lands of the central Wimmera district, its range in Victoria embraces almost the entire State. Wimmera settlers claim that land valued at £12 to £17 per acre for wheat cultivation, has depreciated because of the presence of this weed from £5 to £7 per acre as grazing land unsuitable for wheat growing. In commenting on this claim, Pemberton and Prunster state that these figures are probably extreme, and that little consideration is given to the depreciation of normal wheat lands as a result of lower wheat prices during the last few years. They agree, however, that hoary cress is extremely undesirable, and that its effect on property values is due to reduction in production linked with the difficulty and cost of eradication.

Hoary cress is a gazetted noxious weed for the State of Western Australia, under the name *Lepidium Draba*, a name under which the plant has been known for many years.

THE PLANT.

Hoary cress is a perennial herb with a branched underground creeping and cord-like root-stock which is elongated, and gives rise at intervals to a number of erect leafy branched stems. This creeping root-stock stores food reserves which provide for subsequent growth, and broken portions readily root and provide new plants, which may give rise to new centres of infestation. The leafy stems are erect, mostly ten to sixteen inches high, and bear leaves from the ground level up to the inflorescence. The lowest leaves are usually crowded at the base, oblong-oblanceolate in outline, wavy-margined, up to four inches in length, the leaf-blade tapering into a distinct stalk or petiole; the upper leaves are gradually smaller, without any stalk, the leaf-blade usually encircling the stem at its base, with two laps or auricles which embrace the stem at the leaf-base; the leaves are usually acute at the apex, and more or less hairy with short white hairs lying close to the leaves. The shape, size, and hairiness of the leaves is variable, however, and too much reliance must not be placed on these characters in recognising the plant. Although the name "hoary cress" is an allusion to this hairy or hoary character, some plants are only slightly hairy, and the leaves are quite green. The flowers are arranged in racemes, on slender stalks, the racemes themselves being usually crowded into a terminal corymbose panicle, the axis of each raceme elongating during flowering, so that while the buds are crowded at the apex, the flowers and young pods at the base of the raceme are more or less distant. The cruciform flowers are small, and their shape and structure is much the same as

those of other cruciferous weeds—four sepals, four petals, six stamens and a simple pistil, but the petals are always white, and not more than about twice the length of the sepals, whereas in wild turnip, charlock, and mustard they are yellow. The pod is distinctive, however, being heart-shaped (or reversed heart-shaped) and more or less two-lobed at the base, two-chambered, each chamber bearing one (very rarely two) pendulous seed, and opens by means of two valves, the partition being across the narrow width of the pod. The seeds are suspended from the apex of the cavity of each chamber, are about one-twelfth of an inch in diameter, and egg-shaped, usually slightly laterally compressed, and dark brown to purplish brown in colour, with a dull surface.

The seedling in the seed-leaf stage has a slender thread-like taproot, and the leaves are light green and oval, tapering into a broad leaf-stalk; the first true leaves are oval or almost round, narrowed into a leaf-stalk, light green, with a distinct midrib, and at a later stage the leaf margin becomes wavy or irregular.

In the field the plant may be recognised by the following characteristics, having before one the accompanying illustration (which by the way will serve to explain some of the terms which are unavoidable in description). All Cruciferous plants have four sepals and four petals (white in the case of hoary cress), and the ovary is two-celled longitudinally and inserted at the level of the base of the petals. There are six stamens. In hoary cress each seed-pod contains usually one seed, pendulous from the apex of the cavity. Among the weeds related to hoary cress are three species of *Lepidium*, two of which (Field pepper cress, *Lepidium campestre*, and the common cress, *L. sativium*) occur in flax crops, whilst the third (Shepherd's lucerne, *L. hyssopifolium*) is more widely distributed. These are also white-flowered, with broad short pods, but in *Lepidium* the pod is notched at the summit (often deeply so), the style is very short or none, the pod is more or less keeled or winged on the margin, and the seeds always one in each chamber. In *Cardaria*, the hoary cress, the pod is deeply heart-shaped (rounded at the base in *Lepidium*), not notched at the apex, and the thick style protrudes. In addition the seeds are sometimes two in each chamber, and the plant is hairy. A further distinguishing character in recognising this weed from the others cited is the presence of the thick elongated root-stock.

The name *Cardaria* is taken from the Greek *cardia*, heart, in reference to the heart-shaped fruit; *Draba*, from the Greek *drabe*, is a name used by Dioscorides for this, or some allied plant.

One of the fundamentals of weed control is the recognition of a serious weed when first it appears in order that control measures may be taken before it becomes thoroughly established. The primary object of this article is to assist farmers and others interested to identify hoary cress in the field. Any plant suspected should be forwarded (preferably in flower) to the Government Botanist for identification.

CONTROL.

Hoary cress is capable of spreading rapidly both by means of seed and vegetatively. The extreme difficulty of eradication is due largely to the extensive development and vigour of the rooting system. The main vertical roots penetrate to a depth of 6ft. or more and produce numerous laterals, offshoots from which reach the surface to increase the size of the colony. The persistence of this weed can be gauged from the fact the although investigational work has been conducted in Victoria, over a period of more than 10 years, the problem largely remains unsolved.

HOARY CRESS (*Cardaria Draba*).

A, plant, showing habit (about one-third natural size). B, upper stem leaf. C, flower (much enlarged). D, fruits. E and E1, ovary and section of same. F, fruit (pod) G, seed. H, embryo. I, seedling. (F, G, and I from Bulletin 108, Ministry of Agriculture and Fisheries.)

Between 1931 and 1934 Morgan carried out a series of experiments at the State Research Farm, Werribee, the results of which may be summarised as follows:—

(1) *Salt.*—Seven and a half tons of common salt per acre at Werribee did not give a satisfactory kill. This is attributed to the lack of penetration due to the heavy clay subsoil.

(2) *Chemical Foliage Sprays.*—Arsenic pentoxide proved to be the most effective chemical spray and it was found that there was a suppression of 93 per cent. of hoary cress for a period of 12 months after treatment. The following factors were involved in the success of the treatment:—

(a) Rate of Application.—Maximum results were secured with a six per cent. solution at the rate of 120 gallons per acre.

(b) Moisture Conditions.—A rainless period of at least one week immediately prior to spraying associated with dry soil conditions at the time of spraying.

(c) Time of Spraying.—Application at the flowering stage gave best results.

(3) *Cultivation.*—By using a small scarifier fitted with a weed knife, hoary cress was completely eliminated in two years under Werribee conditions provided the interval between cultivations did not exceed 14 days.

Investigations conducted by the Victorian Department of Crown Lands and Survey between 1926 and 1931 on heavily infested land in the Wimmera showed salting to be effective while regular cultivation at 14-day intervals was also satisfactory though costly. Further experiments are in progress in Victoria.

As the results of the experimental work indicated that arsenic pentoxide is the most satisfactory chemical spray, a programme involving the use of a six per cent. solution at the rate of 120 gallons per acre was commenced in October, 1942, on the area affected at Merredin. Although on each occasion the chemical was applied the above-ground growth was killed, further shoots appeared after a period the length of which depended on the soil moisture and the season of the year. As no appreciable permanent diminution in the density of the weed was secured after several sprayings during the first year, a salting experiment was commenced on portion of the site, while the arsenic pentoxide applications were continued on the remainder.

The salt was applied on 28th October, 1943, at rates of 5, 10 and 20 tons per acre to one thousandth acre plots (10 links by 10 links) randomised along with controls within five blocks. The hoary cress was not affected until 42 points of rain fell during the period 8-10th December. The green shoots then withered at a rate proportionate to the amount of salt applied, those on the 20 ton plots being dry within two days. Further shoots, however, appeared later.

In an attempt to increase the depth of penetration of the salt, a 2in. layer of coarse sand was applied to half of each plot in June, 1944. This was retained in

position by a framework of timber. The following table records the average number of plants per square link on each plot at different stages of the experiment:—

Treatment.	3/5/44.	3/6/44.	28/7/44.	28/8/44.	25/10/44.
20 tons salt	.04	.05	.05	.10	.10
20 tons salt and 2in. sand	—	—	.03	.10	.20
10 tons salt	.10	.17	.25	.48	.53
10 tons salt and 2in. sand	—	—	.23	.50	.88
5 tons salt	.17	.26	.38	.86	.86
5 tons salt and 2in. sand	—	—	.29	.70	1.14
No treatment	.68	1.08	1.41	1.91	1.75
2in. sand	—	—	1.59	2.39	2.31

Although this experiment has not been in progress sufficiently long to enable many conclusions to be reached it is apparent that the 20 tons of salt have effected an appreciable degree of control and that the sanding, so far, has been detrimental rather than advantageous. As the results are more encouraging than with arsenic pentoxide, it has been decided to apply salt at the rate of 30 tons per acre to the affected area.

It is quite apparent from a review of the literature and our own experience that local conditions, particularly relative to soil texture and the development of the root system, have considerable influence on the efficiency of various control measures. In this article, for two reasons, no attempt has been made to discuss methods suitable for controlling extensive areas of hoary cress. Firstly, fortunately the weed is known to occur in this State only on a small area at Merredin and, secondly, little information is available concerning large scale control measures. Further work is in progress in Victoria, which indicates that it will be necessary to alter the system of farming on many properties where hoary cress has become widespread.

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Oat Variety Trials in the Wheatbelt in 1944.

I. Thomas, Superintendent of Wheat Farming.

A. J. Millington, Plant Geneticist.

INTRODUCTION.

Oats are commonly used for more diverse purposes than the other cereals and, in addition to their extensive use for hay and grain, there has been a threefold increase during the past decade in the area of oats sown for green grazing. Much of the fed-off area is subsequently left ungrazed and allowed to mature for either hay or grain. Whilst the war years have witnessed a marked reduction, for various reasons, in wheat acreages, the total area sown to oats has remained constant.

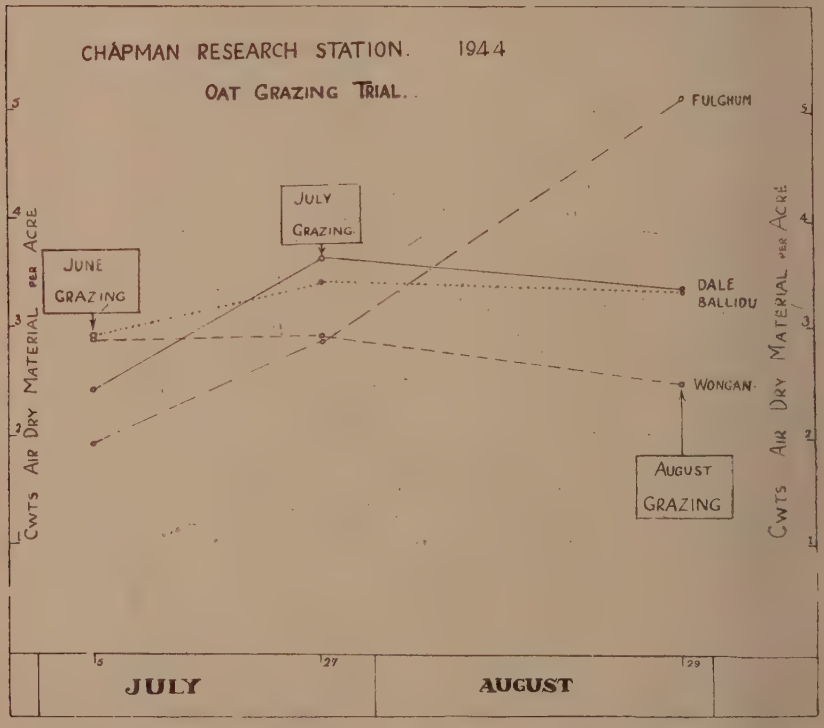
Varieties differ markedly in their suitability for specific purposes, but many farmers prefer a general purpose oat which will give reasonably satisfactory results for either hay, grain or grazing and recovery. Trials conducted by the Department of Agriculture are designed to yield information as to the specific qualities of the different varieties and also their value as general purpose oats.

Variety trials for grain yield only were conducted on the Research Stations at Merredin, Wongan Hills and Salmon Gums and on private holdings in the north-eastern wheatbelt by Messrs. F. V. Knapp and G. L. Throssell of the Department of Agriculture.

Trials for grazing and recovery were carried out on the Chapman and Merredin Research Stations.

Seasonal Conditions.

The opening rains were delayed until late May, which made weed control difficult, whilst June rainfall was in most instances below average. The lack of rain in late August, September and October made the season a very short one.



favouring in general the early and very early maturing varieties. Despite an effective rainfall of less than seven inches, yields of up to 35 bushels per acre were obtained on the Circle Valley soil type at the Salmon Gums Research Station. This soil type is a clay overlain by about six inches of sand and the combination results in very efficient moisture retention, particularly if the falls are fairly heavy. Detailed rainfall readings are given in Table I.

Variety Trial for Grain Only.

These trials were in each instance sown on fallow but owing to the late opening rains wild oats and capeweed made considerable growth at the Merredin and Wongan Hills Research Stations respectively.

When grown for grain the quantity of oats harvested is frequently determined largely by the ability of the variety sown to withstand unfavourable weather at harvest time. The varieties Dale, Ballidu and Wongan bred by the W.A. Depart-

ment of Agriculture are important advances in respect to straw strength over the oats Guyra and Mulga which they are intended to replace. This improvement has not been accompanied by any loss of yielding capacity under ideal conditions. The tabulated yields in Table II show that on all research stations Ballidu is more prolific than Mulga and was superior in all but one Farmers Field Trial. Except at Salmon Gums, Dale has yielded as well as Guyra.

Grazing and Recovery Trials.

The practice in these trials is to cut portion of each plot to ascertain the green feed yield as soon as one variety attains a height of six inches. The plots are then heavily and speedily grazed to a uniform sward by sheep. The oats are subjected to further grazings if seasonal conditions permit and finally left to mature grain. Within limits the greater the number of grazings and the later in the season they are made, the lower will be the subsequent grain yield.

The plots at Merredin were grazed once and recovered reasonably well. At Chapman, where the plots were fed-off twice, the subsequent grain yields were very low and areas which were grazed three times gave negligible recovery.

The choice of an oat variety for grazing will be determined, firstly by the period of the year in which the feed is required and secondly whether it is intended to subsequently close the paddock with a view to harvesting the crop for grain. Where recovery is desired careful management is required to avoid grazing after the crop has commenced to run into ear or the season has become too advanced.

For early winter grazing, best results will be obtained from the variety Wongan, as it grows vigorously in the juvenile stages. Where winter grazing is required the general purpose varieties Dale and Ballidu are satisfactory, but if early spring (August) grazing is necessary, Fulghum will give best results. Fulghum is essentially an oat for grazing and recovery as it is too weak strawed to be considered as a general purpose variety.

For exhaustive grazing where no recovery for grain is anticipated, the Chapman results confirm previous experience that there is little between the commercial varieties. Of the varieties tested Mulga has given inferior results in both grazing and recovery and grain trials to those obtained from Ballidu.

In the tables of results, where the difference in yield between any two varieties is greater than the "difference for significance," it may reasonably be assumed that it is due to variety and not to soil variations, etc.

VARIETAL NOTES.

Late Maturing.

Algerian is cultivated in the southern agricultural and dairying districts for hay, green feed and grain mainly for oatmeal manufacture. Given suitable conditions it is relatively tall growing with purple, moderately slender straw of satisfactory strength. The grain is brown in colour, finely awned, medium in length and plumpness. Algerian is the only late maturing variety to be extensively cultivated in Western Australia.

Mid-season Maturing.

Guyra. Despite its weak and often coarse straw, Guyra has long been the most extensively grown mid-season variety. The plump, dark brown grain possessed by this variety has contributed to its popularity as a feed variety. The awn is coarse and adherent. Guyra is an indifferent variety for green grazing and recovery since the juvenile growth is relatively sparse and the subsequent grain yields, only fair.

Dale.—Over a wide range of conditions Dale has given satisfactory results as a general purpose oat. The particularly strong straw and freedom from shedding make it a suitable variety from the viewpoint of the grower, particularly as these characters are associated with prolific yields of grain.

In the wetter portions of the wheatbelt it has practically equalled Ballidu as the most suitable general purpose variety for grazing and recovery. The grain is light brown in colour, of medium quality and heavily awned. The straw is strong and the variety is suitable for hay.

Fulghum.—As a variety for grazing and recovery, Fulghum differs markedly from the general purpose varieties. The juvenile or leafy phase persists much longer and consequently grazing can be continued into late winter without materially reducing the grain yield. The early growth of Fulghum is not as vigorous as that of the general purpose oats and they are therefore superior for the initial grazings.

The grain is light cream in colour, of moderate quality and awnless. Where grain yields are required it is essential that Fulghum be grazed during the winter to reduce the marked tendency of this variety to lodge.

Early Maturing.

Mulga has over the past decade been the most extensively grown early maturing variety. Its tall growth makes it a satisfactory hay variety but it frequently lodges when left to mature for grain. The grain is light in colour, heavily awned and usually fairly plump.

As an oat for grazing and recovery, Mulga has given very inferior results. The juvenile growth is sparse, and recovery is indifferent, particularly if the grazing has been severe.

Ballidu is superior to Mulga for all purposes except hay. It stands very well in adverse weather without shedding. As a general purpose variety for both green grazing, recovery and grain Ballidu is likely to replace Mulga. Ballidu is a satisfactory variety for hay.

The grain is light brown, coarsely awned and of medium plumpness.

Very Early.

Wongan oats is extensively cultivated as a general purpose variety in the wheatbelt. Its vigorous juvenile growth makes it a suitable variety for green feed where early winter grazing is required. Wongan stands well but may shed to some extent unless harvested as soon as it is mature.

SUMMARY OF RECOMMENDED VARIETIES.

Late Maturing:—Algerian.

Mid-season Maturing:—Dale (general purpose); Guyra (grain); Fulghum (grazing and recovery).

Early Maturing:—Ballidu (general purpose); Mulga (hay).

Very Early Maturing:—Wongan.

ACKNOWLEDGMENT.

Grateful acknowledgment is made to Mr. G. L. Throssell and to Mr. F. V. Knapp, formerly of the Department of Agriculture, for their assistance with the Farmers' Field Trials.

Thanks are due also to the Statistical Branch of the Forestry Department for their analyses of the Grazing Trials results.

The yield data from the Research Stations was kindly supplied by the respective farm managers:—Merredin, Mr. J. H. Langfield; Chapman, Mr. F. Gishubl; Wongan Hills, Mr. D. R. Bateman; Salmon Gums, Mr. F. A. Newman.

TABLE III.

FARMERS' WHEAT TRIALS—NORTH-EASTERN WHEATBELT.

Farmer	R. H. Grant, Bencubbin.		W. Knapp, Kulja.		J. Ferguson, Mukinbudin.	
Variety.	Average Yield per Acre.	Percentage Yield.	Average Yield per Acre.	Percentage Yield.	Average Yield per Acre.	Percentage Yield.
	bus. lb.	%	bus. lb.	%	bus. lb.	%
Ballidu	18 30	99	17 17	142	13 13	138
Mulga	18 36	100	12 10	100	9 16	100
Wongan	16 29	89	13 13	109	11 36	127

TABLE I.

RESEARCH STATION RAINFALL, 1944.

Research Station.	Jan.	Feb.	Mar.	Apl.	Growing Period.							Total to Oct. 31st.
					May.	June.	July.	Aug.	Sept.	Oct.	Total.	
Merredin	21	...	25	15	263	75	287	172	47	6	850	911
Chapman	...	...	36	52	250	226	542	203	46	...	1,267	1,355
Salmon Gums	18	1	11	89	275	44	142	120	57	51	675	808
Wongan Hills	3	...	21	19	249	131	374	193	40	14	1,001	1,044

TABLE II.

OAT VARIETY TRIALS FOR GRAIN ONLY.

Growing Period Rainfall, 1944		1,001 points.				850 points.				675 points.			
Variety.	Maturity.	Wongan Hills Research Station.				Merredin Research Station.				Salmon Gums Research Station.			
		Grain Yield.		Per cent of Guyra Control.		Grain Yield.		Per cent of Guyra Control.		Grain Yield.		Per cent of Guyra Control.	
		Varietal.	Guyra Control.	1944.	Average, 1941–44.	Varietal.	Guyra Control.	1944.	Average, 1941–44.	Varietal.	Guyra Control.	1944.	Average, 1942–44.
		bus. lb.	bus. lb.	%	%	bus. lb.	bus. lb.	%	%	bus. lb.	bus. lb.	%	%
Wongan ...	Very Early ...	...	...	...	...	23 27	10 16	228	116	35 8	31 27	111	85*
Ballidu ...	Early ...	11 15	8 15	135	129	20 19	14 8	144	133	29 12	34 0	87	95
Mulga ...	Early ...	9 32	8 15	114	105	14 8	14 8	100	112	28 6	34 0	83	78
Dale ...	Mid-season ...	7 0	5 30	122	102	11 3	10 16	106	102	27 2	31 27	85	87
Algerian ...	Late ...	8 14	5 30	144	106	...	...	...	...	...	...	...	...

* 1942 and 1944 only.

TABLE IV.

OAT GRAZING AND RECOVERY TRIALS.

Research Station	Merredin.	Chapman.
Growing Period Rainfall	850 points.	1,267 points.
Germination Date	May 29th.	May 22nd.

Variety.	Season of Maturity.	Grazing Yield, 24-7-44.*	Subsequent Grain Yield.		Grazing Yields.*			Total Grazing Yield.	Grain Yield of Twice Grazed Plots.	
					1st Grazing, 5-7-44.	2nd Grazing, 27-7-44.	3rd Grazing, 29-8-44.			
		cwt./acre.	bus.	lb.	cwt./acre.	cwt./acre.	cwt./acre.	cwt./acre.	bus.	lb.
Dale	Late-midseason	...	...		2·44	3·63	3·37	9·44	3	4
Fulghum	Early-midseason	3·48	17	32	1·94	2·86	5·15	9·96	7	24
Mulga	Early	3·61	13	10	...	...	...	...	...	...
Ballidu	do.	4·13	17	36	2·90	3·43	3·35	9·70	4	36
Wongan	Very Early	4·81	16	26	2·86	2·92	2·48	8·25	3	32
Difference for Significance (P — ·05)		0·48	2	16	0·40	0·39	0·62	0·72	...	18

* Expressed as dried grass hay with a moisture content of 10 per cent.

Muresk Agricultural College Pig Feeding Trial IV.

M. Cullity, Superintendent of Dairying. C. R. Dixon, Piggery Instructor.

The trial was arranged in order to compare the efficiency of rations containing different ratios of meatmeal to grain in the raising of bacon pigs, and to verify, if possible, the results obtained with the same rations in Trial III. The grain mixture comprised equal parts of crushed wheat and crushed barley.

Three groups were selected, each containing seven pigs. In each group pigs Nos. 1 and 2 were litter mates, while the rest were singles, though each number was a litter mate to the corresponding numbers in the other groups. Details of feeding are as follow:—

Group 1 .. grain 90 parts, meatmeal 10 parts
Group 2 .. grain 87 parts, meatmeal 7 parts
Group 3 .. grain 95 parts, meatmeal 5 parts

Dicalcic lick formed 2% of all rations and water was always available.

The quantities fed to each group are listed below.

Feed Consumed.

Week ending	Mixture lb.	All 3 Groups.
January 25th	1½	„
February, 21st	1¾	„
February 8th	2	„
February 15th	2¼	„
February 22nd	2½	„
February 29th	2½	„

Week ending	Mixture lb. Group 1.	Groups 2 and 3.
March 7th	2¾	2½
March 14th	3	2¾
March 21st	3¼	2¾

Week ending	Group 1.	Group 2.	Group 3.
March 28th	3½	3¼	3
April 4th	4½	3½	3¼
April 11th	4½	3¾	3½
April 18th	5	4	3¾
April 25th	5	4½	4
May 2nd	5¼	4½	4¼
May 9th	5½	5	4½
May 16th	5½	5¼	4¾
May 23rd	5¾	5¼	5
May 30th	6	5½	5

The trial was continued until the fastest growing groups of pigs approximated 170 lb. live weight. The pigs were then despatched to a bacon factory for slaughtering and curing.

Attention is drawn to the fact that although the average weights of the pigs in all groups at the commencement of the trial were particularly uniform, there was a very marked distinction between these weights at the completion of the trial. A significant difference may be observed between Groups 1 and 2 and a drop of 46.6 lb. in live weight gain between those pigs fed 10 per cent, and those fed 5 per cent. meatmeal.

The principal details relating to rate of growth, food, consumption, etc., are summarised in Table I.

TABLE I.

	Group 1.	Group 2.	Group 3.
	lb.	lb.	lb.
Average weight at commencement of trial	45·57	45·29	45·43
Average weight at end of trial	171·57	143·29	124·86
Average gain per pig	126·00	98·00	79·43
Amount crushed grain consumed per pig	453·60	414·50	402·50
Amount meatmeal consumed per pig	50·40	33·50	20·50
Weight of food per lb. of live weight inclusive ...	4·0	4·6	5·3
	s. d.	s. d.	s. d.
Total cost of feed per pig	39 8	34 9	32 1
	d.	d.	d.
Average cost per lb. of live weight inclusive ...	3·78	4·26	4·84

Once again it was shown that the group which made the most rapid growth (Group 1) also proved the most efficient for converting food into meat using 4 lb. of food for each 1 lb. live weight increase. With a decrease in the percentage of meatmeal fed the amount of feed required to produce 1 lb. live weight increase was slightly higher, but it should be borne in mind that during a period of meatmea lshortage like the present, it is not possible to feed the quantity of meatmeal which will ensure maximum growth rate and economy in the use of feeding stuffs. Every effort should be made to supplement the deficiency of meatmeal with green grazing either of clover pastures or cereal crops.

An analysis of the cost of feeding is shown in Table II. Six pigs were slaughtered in Group 1 and four in each of the other two groups. For purposes of comparison the value and cost of feed for only four pigs is shown in Group 1.

TABLE II.

PROFIT OVER COST OF FEED.

Group No.	Value of Pigs.	Cost of Feed.	Margin-value over Cost of Feed.	Per Pig.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1	20 13 6	7 18 8	12 14 10	3 3 9
2	18 11 3	6 19 0	11 12 3	2 18 1
3	17 17 9	6 8 4	11 9 5	2 17 4

The largest profit, as in the previous trial of this nature (*Journal of Agriculture*, June, 1944) was obtained where the standard ration (10 per cent. meatmeal) was used. The cost of feeding Group 2 was slightly higher and the margin of profit 5/8d. per pig lower than for Group 1. The difference in the profit between Groups 2 and 3 of 9d. per pig is remarkably small in view of the higher proportion of meatmeal fed to the former group.

Conclusions.

1. The conclusion reached in previous trials that 10 per cent. meatmeal in a grain mixture allowed more rapid and profitable growth than smaller proportions of meatmeal has been confirmed.

2. While a mixture containing only 5 per cent. meatmeal resulted in slower growth and a smaller profit, the margin of value over the cost of feed amounting to £2 17s. 4d. per pig still allowed an attractive profit.

Muresk Agricultural College Pig Feeding Trial V.

R. R. Rutherford, Farm Manager and Demonstrator, C. R. Dixon, Piggery Instructor.

The trial was arranged to obtain information regarding—

(a) The value of whole grain compared to crushed grain for feeding pigs.

(b) The ability of pigs to develop satisfactorily using a 5 per cent. meatmeal ration, together with ample green feed (grazing).

(c) Any difference in food consumption between pigs hand fed and self fed.

(d) The efficiency of self-feeders.

Three groups were selected each containing 10 pigs from nine litters, there being a representative of each litter in each group. The groups were run in one and one-quarter acre paddocks adjacent to each other. The paddocks were sown down with Cape barley at the rate of 70 lb. per acre in mid-April and the resultant crop was approximately five inches high when the trial commenced on 31st May, 1944.

Each paddock had automatic watering and was equipped with a 44-gallon oil drum type of self-feeder (capacity approximately 240 lbs. of crushed grain) as described in Western Australian Department of Agriculture Journal of December, 1943. These feeders were replenished as soon as they were emptied.

The groups were fed rations as follows:—

Group 1.—Whole grain 90 parts, meatmeal 10 parts.

Group 2.—Crushed grain 90 parts, meatmeal 10 parts.

Group 3.—Crushed grain 95 parts, meatmeal 5 parts.

All of the above rations contained a 2 per cent. mineral supplement of di-calcic lick.

The trial was continued until 23rd October, when the pigs averaged approximately 200 lb. live weight. At this stage the pigs were despatched to a bacon factory for slaughter and dressing.

The principal details relating to rate of growth, food consumption, etc., are summarised in Table 1.

Table 1.

	Group 1. lb.	Group 2. lb.	Group 3. lb.
Average weight at commencement of trial	55·1	55·0	55·0
Average weight at end of trial	194·9	203·4	193·0
Average gain	139·8	148·4	138·0
Total weight of wheat consumed (10 pigs)	4,450·0	3,190·0	3,095·0
Total weight of barley consumed (10 pigs)	1,670·0	1,670·0	1,750·0
Total weight of meatmeal consumed (10 pigs)	680·0	540·0	255·0
Average feed per lb. of live weight increase	4·94	3·64	3·70
Dressing percentage	69·46	72·1	71·0

Group 2 made the most rapid growth, followed by group 1 (whole grain and 10 per cent. meatmeal) which was only 1.8 lb. per pig better than group 3, although it used 42.5 lb. of meatmeal and 127.5 lb. of grain more per pig.

Group 2 (crushed grain and 10 per cent. meatmeal) were the most efficient for converting food into meat using 3.64 lbs. of food for each lb. of live weight increase. Group 3 (crushed grain and 5 per cent. meatmeal) was next using 3.70 lbs. Pigs in group 1—on whole grain—were not as efficient in this respect as they required 4.94 lbs. of food for each lb. of liveweight increase; that is they required an increase of 1.3 lb. of food more than group 2 to produce 1 lb. of liveweight increase. If this 1.3 lb. of food had been fed as in group 2, it would have produced approximately 1/3 lb. of live weight increase.

Dressing percentages are seen to follow closely the effective utilisation of food by the various groups, i.e., group 2, 72.1; group 3, 71; group 1, 69.46.

The growth of group 3 using an average per pig of 484.5 lb. of grain and 54 lb. of meatmeal compares very favourably with group 2, using an average per pig of 486 lb. of grain and 54 lb. of meatmeal. This indicates that where good green grazing is provided, satisfactory results can be obtained using a ration containing only 5 per cent. of meatmeal, as apparently the pigs are able to obtain near their optimum protein requirement by utilising that from the green crop in addition to that in the meatmeal. This conclusion has been confirmed by observation in the piggery during periods of meatmeal shortage.

TABLE 2.

PROFIT OVER COST OF FEED.

	Group 1.	Group 2.	Group 3.
	£ s. d.	£ s. d.	£ s. d.
Average cost of feed per pig	2 11 6	2 1 4	1 17 10
Cost of crushing grain (at 3d. per bushel) ...	...	0 2 2	0 2 2
Total cost of feed per pig	2 11 6	2 3 6	2 0 0
Average value per pig (at 9d. per lb. dressed weight)	5 1 3	5 9 2	5 1 9
Average profit over cost of feed	2 9 9	3 5 8	3 1 9
Average cost per lb. of live weight increase ...	4·42d.	3·52d.	3·48d.

An analysis of profit over cost of feeding is shown in Table 2. The greater profit was obtained where the standard ration (10 per cent. meatmeal and 90 per cent. grain) was used (Group 2). The cost of feeding Group 2 was 8s. per pig less than Group 1 and Group 3, 11s. 6d. per pig less than Group 1.

Group 2, with £3 5s. 8d., showed the largest profit over cost of feed, being 15s. 11d. per pig more than Group 1 (on whole grain), which had consumed 126 lb. of grain and 14 lb. of meatmeal more per pig.

It is obvious, therefore, that the feeding of whole grain—even with the saving of the cost of crushing—is unsound practice, and to a farmer handling 50 baconers would mean a loss over crushed grain feeding as in Group 2 of £39 15s.

Table 3 represent an average of the results of 10 pigs hand fed, i.e., twice daily, on a ration of 90 parts of crushed grain and 10 parts of meatmeal, in M.A.C. Pig Feeding Trials Nos. 3 and 4.

TABLE 3.

	lb.
Average weight at commencement of trial	47·66
Average weight at end of trial	177·035
Average gain	129·4
Average total amount of grain consumed per pig	413·45
Average total amount of meatmeal consumed per pig	45·9
Average weight of feed per lb. of live weight increase	3·55

A comparison between Table 1, Group 2 (self-feeding) and Table 3 (hand-feeding twice daily) can now be made to ascertain whether the commonly held view—that self-feeding is wasteful, and that pigs take far more feed than they require—is correct.

Table 1, Group 2 (self-fed) pigs required and took an average per pig of 3.64 lb. of feed for each lb. of liveweight increase, whilst pigs in Table 3 (hand-fed) took an average per pig of 3.55 lb. of feed for each lb. of liveweight increase, or .09 lb. of feed less per lb. of liveweight increase.

This .09 lb. difference may be considered negligible when the economics of labour and time saving are considered.

CONCLUSIONS.

1. Whole grain feeding showed a loss of 15s. 11d. per pig in comparison with crushed grain feeding and is therefore a practice which cannot be recommended.

2. Good green grazing, together with a ration containing 5 per cent. of meatmeal, proved satisfactory and indicated that pigs fed thus could obtain their optimum protein requirements by the utilisation of green grazing.

3. Self-feeders were not wasteful when compared with hand-feeding. The difference of .09 lb. of feed per lb. of liveweight increase being of no economic importance.

4. Self-feeders proved an efficient method of feeding groups of pigs and the saving of time and labour over hand-feeding methods were considerable.

ACKNOWLEDGMENT.

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Cow Peas.

(*Dolichos sinensis.*)

CULTIVATION AND UTILISATION.

H. G. ELLIOTT, Agrostologist.
Revised from Leaflet No. 386, by G. K. Baron Hay.

INTRODUCTION.

The cow pea, which is in reality a bean, is indigenous to tropical regions and has been cultivated in Africa and Asia for human food for many centuries. It is now commonly grown for pasturage, green feed, hay and ensilage for feeding to all kinds of stock, and as a soil improving crop. The seed can be utilised for human and stock food.

CLIMATIC AND SOIL REQUIREMENTS.

For best growth, cow peas require climatic conditions which are similar to that for growing a successful crop of maize for green feed or grain. At any stage during the growing period cow peas are subject to damage by frosts or extreme

cold weather conditions, but excellent growth will continue throughout the summer months until it is checked by the approach of the cold weather. Generally speaking cow peas are more drought resistant than maize, provided adequate intercultivation of the soil is practised during the growing period. As a rule cow peas yield a crop of very heavy succulent fodder which can be grazed or preferably cut, and used in conjunction with maize, sorghum or elephant grass, as a green feed.

Cow peas are not exacting in soil requirements, although like most crops, do best on heavy rich soils, and will thrive and produce well on practically all classes of summer moist ground or on land where irrigation water can be applied, but for success it is essential that the soil be well drained and thoroughly prepared.

On poorer soil types heavy yields of green material cannot be expected, but heavier seed yields are likely to be obtained. Farmyard manure liberally applied to the ground and well worked in prior to planting the seed is advantageous in the production of heavy yields of green material.

Soil Preparation.

Whether planted alone, or in association with maize, it is essential that a firm, smooth, fine seed bed be prepared. If possible the ground should be ploughed to a depth of not less than 5 in. at least four to six weeks prior to planting. After a short fallow period the ground should be worked down with disc or tyne types of cultivators, rolled and harrowed two or three times prior to planting. Good even germination and subsequent stand of cow peas are assured if the seed bed is fine, moist and warm.

Time of Planting.

This depends on the climatic conditions of the districts in which the crop is to be grown. Farmers should delay plantings until all danger of frost has passed and the soil is sufficiently warm so as to promote a good even germination of the seed. With early planting, poor germination and uneven non-vigorous stands will occur, this being due to some of the seed rotting owing to the soil being cold and those which do germinate producing stunted plants owing to the cold conditions.

Rate of Seeding.

When broadcasted approximately 45 lbs. of seed per acre is required, the rate varying from 30-60 lbs. per acre according to the variety and size of seed used. For preference and economy planting in rows from 30-36 in. apart is advocated, the rate of seeding would then be about 15-20 lbs. per acre, again according to the size of the seed and variety used. The depth of sowing should be from 2-3 in. as for maize.

Fertilising.

Cow peas being legumes and providing the necessary nitrogen-fixing bacteria are present in the soil, or the seed has been inoculated prior to planting require principally a phosphatic fertiliser. At the time of planting a small quantity of nitrogenous fertiliser with the superphosphate is advantageous. The mixture recommended is about 56 lbs. of sulphate of ammonia or equivalent of nitrate of soda with 2-3 cwts. of superphosphate per acre, applied at the time of seeding.

Inoculation.

Cow peas, like other legumes, can obtain their nitrogen requirements from the free nitrogen of the air, which is fixed and made available to them by nitrogen-fixing bacteria. Inoculation, therefore, with the desirable strain of bacteria is essential, and cow peas cannot be a complete success without it.

"Cultures" for cow peas are being prepared in the laboratories of the Plant Pathologist of the Department, and applications for culture should be made to the Department of Agriculture, and accompanied by a fee of 1s. 6d.; this being sufficient to treat 40 to 60 lbs. of these peas.

Variety.

The variety principally used and generally recommended is that known as "Black Eye" or black seeded variety, but other varieties such as "Whippoorwill," "New Era" and "Brabham" have also given excellent results.

Cow Peas and Maize grown by Mr. S. F. Russell, Serpentine.
Photo taken 10 weeks after planting.
Block taken from Leaflet No. 386.

Subsequent Treatment.

Much of the success of the crop will depend on frequent cultivation to conserve the soil moisture and keep down weeds. The cultivations begin soon after germination commences and continues until the spread of the plant prevents further working, which is usually five to six weeks from date of planting.

Growing in Association with Maize.

Cow peas grow very successfully in association with maize and yields of up to 33 tons per acre of green material have been obtained from this combination.

The accompanying photograph shows a crop 10 weeks after planting.

Sorghum also can be used in place of maize, and the rate of seeding for rows 3 ft. apart would be 18 to 20 lbs. maize or 10 lbs. sorghum with 8 to 12 lbs. cow peas per acre. Cow pea seeds may be sown in the same rows as maize, but it is preferable to sow in separate rows. The rate of growth of cow peas and maize is approximately the same, so that the alternate rows can be cut together, the mixture providing a succulent and high protein ration for milk production.

Seed.

Cow pea seed has a high feeding value but generally is not used for this purpose owing to its high price. It is used in the Southern States of U.S.A. as a palatable and nutritious human food.

Time of Harvesting.

Owing to uneven ripening it is often difficult to judge when the crop is at the proper stage of maturity to cut for seed. It can be stated that in general the crop should be harvested when half to two-thirds of the pods on the vines are matured. Some loss of seed from shattering of the over-ripe pods will occur but more seed will be obtained this way than if the crop is harvested before a large percentage of the pods are ripe.

After cutting with a mower the vines should be allowed to cure until thoroughly dry and then stacked. When time permits thrashing and cleaning of the seed by means of a grain separator is carried out.

Yields of from 10 to 15 bushels per acre can be obtained, and the straw after thrashing for seed is a valuable feed for all kinds of stock.

Pasture.

It is not generally recommended to use cow peas as a pasture but under certain conditions it can be carried out successfully. The best time for turning stock on to cow peas is when the crop is considered ready for hay cutting. As with most green crops at this time of the year, there is a danger from bloat with cattle or sheep.

Pigs do particularly well on cow peas but they are usually turned on to them when the seed is more mature than for large stock.

Hay.

Hay of excellent quality and value, equal to other leguminous crops, and greatly relished by stock can be made from cow peas. They are ready for cutting when the majority of the pods are full grown and turning yellow. Mowing is done with the standard type of mower, raking and windrowing and finally cocking, prior to stacking for curing, is necessary for best results.

Superphosphate—Immediate Ordering Essential.

K. NEEDHAM, Agricultural Adviser.

During 1943-44 rationing year farmers were requested to complete their applications for fertiliser early and to follow this up with an early lodgment of orders. The quota for 1943-44 was approximately 120,000 tons, but the response to early ordering was not as successful as was hoped. As a result, both the railways and fertiliser manufacturers were working to full capacity to despatch the total quota and both these parties experienced considerable difficulty in meeting the despatch requirements.

For 1944-45 Western Australia has been allocated approximately 190,000 tons of superphosphate, and the fertiliser manufacturers and railways, who are again experiencing similar manpower and transport difficulties to last year, will be asked to manufacture and transport 70,000 tons more than they did last year. It became obvious to both of these parties that a schedule of monthly despatches would have to be drawn up and strictly adhered to if the full quota was to reach the farmers in time, when it was realised than an increased tonnage had to be handled with the same facilities as those available during 1943-44. The following schedule shows.

the total despatch of superphosphate, exclusive of mixed manures, from all works, which must be attained between the months of December and June if the full quota is to be received by farmers:—

Month.	Tonnage.
December	13,450
January	24,750
February	37,500
March	41,500
April	39,000
May	20,700
June	6,100
	183,000

Early in December a very poor response had been received to the appeals made by this department and the fertiliser manufacturers and distributors for immediate ordering and despatch of superphosphate, and the position was becoming so serious that a meeting was called, at which the fertiliser manufacturers and distributors, the Railway Department, Manpower Directorate, the Royal Agricultural Society, Primary Producers' Association and Department of Agriculture were represented.

The Commonwealth Government, by means of direct representation to the British Government, was able to arrange for extra shipping to make available increased supplies of superphosphate to Australia, resulting as it did in the Western Australian quota being increased by 70,000 tons. The object of the meeting was to discuss a system by means of which it would be ensured that the increased quota received as a result of these direct representations to the British Government would not be lost to the State and would be despatched in full to farmers.

It was realised that farmers prefer their fertilisers to be despatched during February, March and April in order that the superphosphate may not remain on the farm for any considerable period before use. From the above schedule it will be seen that the manufacturers and the Railway Department are endeavouring to transport the maximum quantity possible during these three months, averaging about 39,000 tons per month, in an endeavour to meet as far as possible the requirements of farmers.

Difficulties associated with early ordering of superphosphate such as the rotting of bags, setting, transport difficulties associated with back-loading from wheat and the completion of financial arrangements before the end of February were fully appreciated and thoroughly discussed by representatives at the meeting. Nevertheless it was apparent that, unless the target of despatch set for each month was obtained, it would not be possible to adhere to the schedule of despatches in the following months, nor would it be possible to make up the lee-way lost. It was obvious, therefore, that if the tonnage despatched in any one month was below the target, the following month would be affected to the percentage of the decreased despatch in the previous month.

It was resolved at this meeting that the only practicable solution was to adopt the principle that where orders for fertiliser in any month fall short of the prepared schedule of monthly despatch, such shortage should be allocated evenly amongst all outstanding orders. This means, in effect, that if the despatch for December is five per cent. less than the target, all orders listed for despatch in

January would have to be reduced by a percentage of the face value of the permit, as the tonnage carried over could not be handled. This principle was endorsed by representatives who attended the meeting.

In another State of the Commonwealth where a similar position arose it was necessary for the authorities to advise farmers summarily that their superphosphate would be despatched on a certain date, but it is hoped that this action will not be necessary in Western Australia. Furthermore, it is considered that, provided farmers are prepared to order fertiliser early in the season, they should not be penalised if the works or railways should not be able to effect delivery.

The seriousness of the position by this stage will no doubt be fully appreciated by all farmers, and they are requested, therefore, to submit their orders for superphosphate for early despatch and particularly for delivery during December and January. If this is done, they will be assured of the full quota being received. However, should these orders be insufficient to maintain the required rate of despatch, subsequent orders will be reduced on a percentage basis determined by the amount of the reduced quantity despatched. Unless farmers order for early despatch they run the risk of not receiving the full quota allocated, which means that the extra 70,000 tons which has been made available for Western Australia will not reach its proper destination. It is considered that the extra work which would be involved in tipping the superphosphate and re-bagging prior to use would very substantially offset the risk of receiving a reduced quota.

Broom Millet.

H. G. Elliott, Agrostologist.

*Revised from Leaflet No. 201 by G. K. Baron Hay.

Broom Millet (*Andropogon sorghum vulgare*) is grown for the brushes on which the seed is produced and not for feed, although both the seed and stalks have some value as a stock food. It is an annual non-saccharine variety of sorghum, very similar to maize when young, but has thinner stems and narrower leaves. The male and female flowers occur on the one plant.

In W.A. the acreage of broom millet grown annually varies considerably but it is never very large. During war time the price of broom and seed has been very high and farmers have been obtaining very remunerative returns per acre.

Origin.

The origin of Broom Millet is not known but it has been grown in Europe for more than 350 years.

Climatic and Soil Requirements.

Broom millet can be grown under conditions similar to that required for the growing of maize for grain. The best results are obtained from deep, rich, well drained soils and under these conditions the plant makes rapid unchecked growth. It is capable, however, of growing on a variety of soils from sandy to gravelly, providing the ground is retentive of moisture or can be irrigated and well fertilized. On poor, badly drained ground which dries out, growth is slow and uneven and there is a general tendency for the crop to become stunted and diseased. To obtain best results—that is an even crop of uniform ripeness—a soil uniform in character and fertility is essential.

Soil Preparation.

For best results the ground must be thoroughly prepared to a depth of five inches and have a fine firm seed bed, similar to that for maize. This is obtained by ploughing the ground thoroughly about 4-6 weeks before sowing and then prior to seeding, working down with the cultivator, rolling and harrowing. Weeds must be destroyed as the presence of these in the early stages interferes with the growth of the young plants.

Fig. 1.
Broom Millet—White Italian.

Time of Planting.

The seed should be sown when the danger of frost is over and the land is sufficiently warm for the seed to germinate at once. It should be sown at the same time as maize. Experiments conducted in Western Australia indicate that Sep-

tember, October and November are the most favourable months to sow in the South-West of this State. In Denmark and that coastal strip where frosts are rare, planting may very well be carried out in September. If sown too early and there is not sufficient heat in the soil to cause the seeds to germinate they will either rot or the young seedlings produced will be so weak that the weeds, if present, will overgrow and ultimately smother them. Approximately five months is required for the plant to attain maturity.

Seeding.

The seed should be planted in shallow drills 3ft. 6in. or 4ft. apart, according to the district and quality of the land.

Seed may be sown either by hand or with a machine, the single row maize planter, which may be fitted with suitable plates, effecting the purpose well. Machine planting is preferable, as it sows the seed regularly, buries it at a uniform depth, and compacts the soil around the seed, thus assisting quick germination.

Care should be taken to plant the seed deep enough to place it in the damp soil beneath the dry surface mulch, generally 1 to 1½ inches deep.

With a drill, using sound seed, approximately 4 lbs. per acre will be required. When the seed is planted in the drills by hand, the quantity should be increased to 6 lbs. per acre.

When plants are 8 inches high, they should be thinned out to 4 inches between them on good soils up to 8 inches on poorer types of soil. Thinning out of the plants is reflected in the quality of the fibre; a thick stand produces spindly and weak thin fibre.

Fertilizer.

Broom millet is a gross feeder, and the soil should be well supplied with those plant foods most commonly deficient, namely, nitrogen (in organic matter) potash, and phosphoric acid.

The character of the soil would to a certain extent influence the system of manuring. Clay soils are usually well supplied with potash, swampy soils usually contain abundant organic matter, while sandy soils would lack both these constituents. It may be taken for granted, in Western Australia, that a phosphatic manure will be required on all soils. Farmyard manure can be applied with advantage and the plant will stand heavy dressings with safety. Because of this, broom millet is a suitable crop to succeed a crop of field peas or subterranean clover. Generally an application of 2 to 3 cwt. per acre superphosphate, with ½ to ¾ cwt. per acre sulphate of ammonia or its equivalent in nitrate of soda is recommended. On sandy soils this may be further supplemented with ½ cwt. per acre sulphate of muriate of potash.

Intercultivation.

Good cultivation of the soil between the rows is necessary to keep down all weed growth, and to retain moisture. Intertillage should commence early, and continue, especially after summer showers, till the seed heads are forming. At this latter stage the plant requires good conditions for growth, as the brush is directly affected by reverses at this stage.

The usual methods employed for the cultivation of maize are satisfactory for broom millet. The maintenance of clean weed-free ground is desirable.

Two or three cultivations during the growing period are usually necessary, but where weeds are present intercultivation should be carried on until the seed heads are forming.

Head Bending.

One of the principal dangers with broom millet is of the fibres of the brushes bending on account of the weight of the seed thereby causing defective brushes, but these defects can be overcome to a great extent by bending the brushes over so that the weight of the seed will keep the brush fibres hanging straight down and close together. This operation should be carried out just as the brush fibres are starting to spread. For best results bend the stalks at a point about 12in.

Fig. 2.
The figure on the left shows a head of millet bent correctly by hand and that on the right an example of where this practice would have been profitable.

below the base of the brush between the joints or nodes of the stalk. Avoid breaking the stalk or bending at too sharp an angle. This important operation is neglected by many growers with a consequence that they have a large percentage of their crop spoilt.

Harvesting.

Harvesting is either carried out by cutting or pulling according to the varieties grown. About 10-14 days of man labour are required in America to harvest, cure, thresh and bale a ton of cured brush. A ton of cured brush contains 40,000 to 70,000 heads, each brush or head must be pulled or cut separately.

The brush turns from pale yellow to green before maturity and should not be harvested until the whole brush from the tips down to the knuckles is green. If harvested whilst the fibres are still yellow they will be weak and flabby at the bottom. The seeds are at about milk stage when ready to harvest. Four or five days after this ripe stage the brush gets over-ripe and begins reddening.

Where a large area is to be harvested almost invariably each quality will be obtained, as the heads last harvested will be mature. At this stage the fibre is a straw or flesh colour, and is a little inferior in quality. In normal seasons it will be found that this quality sells as readily as the prime, and the value of the seed as poultry feed more than makes up any loss.

Where only a small area is grown it is recommended to harvest the crop just before the seed is mature, thus obtaining a prime article.

The actual harvesting should be carried out in warm dry weather, as if stacked while damp, the fibre becomes discoloured in a very short time.

This State is admirably suited from a climatic viewpoint for the growing of this crop, as our conditions for harvesting are almost invariably good.

During the harvesting the sheath enclosing the base of the brush should be removed at the time of cutting as this facilitates drying, and deprives aphidae of shelter, which insects are almost invariably found in crops of millet.

Tabling.

Standard broom corn varieties must be cut from the stalk. This is usually done by tabling. Tabling is used when the plants are over 9 feet high. A man walking backwards and bending the stalks diagonally across one another with the brush hanging over the edge of the "table." The brush is then cut from the stalks and placed in bundles on the "table." The table is about 2½ to 3 feet high. The brush is left on the table for 24 hours or less and then carted to the sheds where it is threshed and placed on slats in sheds to cure.

Inexperienced men harvest about 2/5 acre per day. One man can table and cut 1 acre in 15 to 25 hours. One ton of green brush is equivalent to about 500 lb. of cured brush with seeds removed.

If the crop is less than 9 feet high it is simply broken in such a way that the brush hangs at about waist height. This method also helps weak brush to preserve the straightness of fibre necessary. Stalks less than 7 feet are usually cut without even breaking.

Hackling or Threshing.

"Hackling" is the process of removing seed. A home-made contrivance for this work may be easily constructed. Such a machine consists of a tough wooden drum about 18 inches long and 15 to 18 inches in diameter, bound at each end to prevent splitting. Stout nails, with the heads removed, are driven at regular but "staggered" intervals, leaving a small space between each. This is mounted with a steel axle, and revolves in a wooden or other bearing, placed in a stout frame, high enough for easy turning. It requires to be driven at high speed, and this may be attained by attaching the handle to a large cogwheel, which engages with a much smaller one fixed to the axle of the drum, or may be driven by some power plant.

Growers of small areas will find that a steel comb, suitably mounted, or even a cleft stick, which is held with one hand to give the requisite pressure, will answer the purpose.

Curing.

Threshed green brush placed in the shed, loses about ½ of its weight in the form of evaporated water before the brush is dry enough for baling. This requires 10-14 days under ordinary conditions but longer if the weather is damp. Brush left longer than 24 hours in the field is likely to become bleached, otherwise the longer it is left in the field, the shorter is the curing period.

The brush is placed on the slats within the shed 2in. to 3in. thick. If piled too thickly it becomes "shelf burnt" and discoloured on account of heating.

Curing is sometimes done in ricks but this material is usually poorer in quality, bleached and sometimes discoloured by rain. Under favourable conditions it may be of excellent colour and appearance. Ricks are 3ft. to 5ft. high and 4ft. wide at the bottom and tapering upwards. The seed ends are placed outwards.

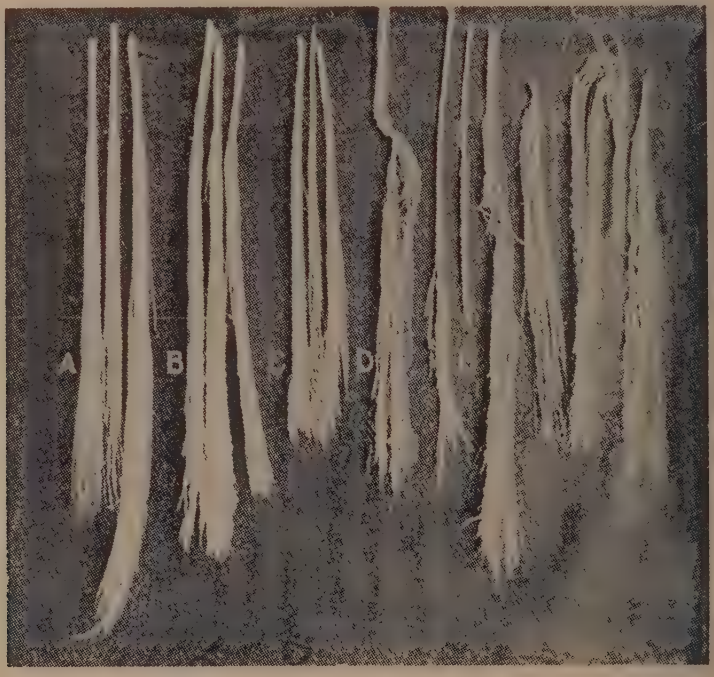

Fig. 3.
Samples of millet heads, from prime (A and B) to rubbish (D, E, and F).

Grading.

It is important that the farmer grade his broom millet brushes carefully according to market types. Green coloured brush should be segregated from golden-coloured brush and classing each into appropriate grades.

Market Types.

Market types of brush are classified as follows:—

"Insides" or "handle corn" usually short and sometimes rather stemmy and is used for the inside portion of the broom.

"Covers" or "turnovers" is usually somewhat longer and is used for making the shoulders of a broom.

"Hurl" is the long fine brush used for making the outside of the broom.

Quality.

Factors determining quality are:—

Colour.—A bright pea green colour free from discolouration is best.

Fibre.—Medium length brush brings a better price than extremely long or short brush. Brush shorter than 17in. used for underwork. Brush longer than 24in. must be used for warehouse brooms or else trimmed down. Whisk dwarf fibre is 12in to 15in. long.

Fine fibres 1/16in. or less in diameter required. Fine branches near the tip are desirable. All fibres should be attached to the stem at the same point forming a well defined knuckle.

Baling.

The various grades should be baled separately and all seed removed. In placing the brushes in a press, care must be taken to protect the fibres. The brush is laid with the butt ends outwards and the heads overlapping in the middle. Battens may be placed on the top and bottom of the bales and when pressed, tied with at least three strands of No. 10 wire. A bale of 36in. long by 18in. deep by 30in. wide, weighing approximately 112 lb. is usual and satisfactory.

Yield.

The yields range from 8-15 cwts. of good fibre per acre. At the present time prime hurl is worth about £70 per ton and will probably remain at that price until after the war.

Seed has been selling commercially in W.A. for foodstuffs at from 10s. to 16s. per cwt.

The portion of the plant left in the field can be chaffed for roughage for stock or preferably burnt to destroy any pests that may have been present in the crop. The ash is of value as a fertiliser as it is rich in potash.

Variety.

The variety recommended for growing in this State is the white Italian. This variety is suited to most soils and yields well. Seed is readily obtained in this State.

Seed for Future Planting.

The practice of reserving a quantity of seed from the bulk obtained by scraping the seed from all heads harvested is not a good one. This practice leads to poor yields, inferior brush, and therefore unprofitable returns. Just before harvesting it is recommended that the grower inspect his crop, and cut enough heads from the best plants to supply sufficient seed for next season's planting. As a guide in this direction approximately one-third (by weight) of a complete head consists of fibre. The points to be looked for are long, fine, straight fibre; a heavy yielding brush; seed heads compact; seed light brown and well filled out; freedom from disease. These heads should then be thoroughly dried, and stored in a bin (mouse-proof) with a liberal sprinkling of napthalene powder to guard against insect pests.

Fertilisers.

The following fertilisers have been registered at the Department of Agriculture under the Fertilisers Act, 1928, for the year commencing 1st November, 1944.

Name of Fertiliser.	Reg. No.	Brand.	By Whom Registered.	Nitrogen (N) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O) as		Cash Price per ton on Rail at Works or Perth.
				Nitrate.	Ammonia.	Blood and Bone.	Bone Dust.	Water Sol.	Citrate Sol.	Acid Sol.	Total.	Sulphate.	Muriate.	
				%	%	%	%	%	%	%	%	%	%	£ s. d.
A.—MINERAL.														
1. NITROGENOUS.														
(a) *Nitrogen as Nitrate:*														
Nitrate of Soda	8	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	15·50	....	....	....	....	....	....	....	....	....	18 10 0*
Do. do.	17	ML in diamond	do. do.	15·50	....	....	....	....	....	....	....	....	....	18 10 0*
Do. do.	26	C.S.M.L.	do. do.	15·50	....	....	....	....	....	....	....	....	....	18 10 0*
Do. do.	33	Cresco	Cresco Fertilisers (W.A.), Ltd.	15·50	....	....	....	....	....	....	....	....	....	18 10 0*
Do. do.	53	Champion	R. Dundas Smith & Son	16·00	....	....	....	....	....	....	....	....	....	Price on application.
(b) *Nitrogen as Ammonia:*														
Sulphate of Ammonia	7	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	....	20·50	....	....	....	....	....	....	....	....	18 10 0*
Do. do.	16	ML in diamond	do. do.	....	20·50	....	....	....	....	....	....	....	....	18 10 0*
Do. do.	25	C.S.M.L.	do. do.	....	20·50	....	....	....	....	....	....	....	....	18 10 0*
Do. do.	34	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	20·50	....	....	....	....	....	....	....	....	18 10 0*
2. PHOSPHATIC.														
(a) *Rock Phosphate:*														
Phosphate Powder	39	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	....	....	....	....	....	27·50	27·50	....	....	7 8 6*
(b) *Superphosphate:*														
Florida Superphosphate 18%	1	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	....	....	....	....	14·00	2·50	1·50	18·00	....	....	5 3 6*
Superphosphate 18%	10	ML in diamond	do. do.	....	....	....	....	14·00	2·50	1·50	18·00	....	....	5 3 6*
Do.	19	C.S.M.L.	do. do.	....	....	....	....	14·00	2·50	1·50	18·00	....	....	5 3 6*
Do.	31	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	....	....	....	14·00	2·50	1·50	18·00	....	....	5 3 6*
(c) *Rock Phosphate and Superphosphate:*														
50/50 Phosphate	32	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	....	....	....	7·00	1·50	13·50	22·00	....	....	6 16 0*

* On Rail at Works.

FERTILISERS—*continued.*

Name of Fertiliser.	Reg. No.	Brand.	By Whom Registered.	Nitrogen (N) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O) as		Cash Price per ton on Rail at Works or Perth.
				Nitrate.	Ammonia.	Blood and Bone.	Bone Dust.	Water Sol.	Citrate Sol.	Acid Sol.	Total.	Sulphate.	Muriate.	
				%	%	%	%	%	%	%	%	%	%	£ s. d.
3. POTASSIC.														
(*a*) *Potash as Sulphate:*														
Sulphate of Potash	29	C.S.M.L.	Cuming Smith & Mt. Lyell F.F., Ltd.	....	....	....	....	....	....	....	....	37·00	....	20 8 0*
Do. do.	41	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	....	....	....	....	....	....	....	37·00	....	20 8 0*
(*b*) *Potash as Muriate.*														
Muriate of Potash	9	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	....	....	....	....	....	....	....	....	....	62·00	30 17 4*
Do. do.	18	ML in diamond	do. do.	....	....	....	....	....	....	....	....	....	62·00	30 17 4*
Do. do.	27	C.S.M.L.	do. do.	....	....	....	....	....	....	....	....	....	62·00	30 17 4*
Do. do.	40	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	....	....	....	....	....	....	....	....	60·00	29 17 5*
4. NITROGEN AND PHOSPHORIC ACID.														
Potato Manure, "C"	2	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	..	3·00	..	..	11·50	2·00	1·50	15·00	..	..	7 17 10*
Do. No. 2	11	ML in diamond	do. do.	....	3·00	....	....	11·50	2·00	1·50	15·00	....	....	7 17 10*
Do. "C"	20	C.S.M.L.	do. do.	....	3·00	....	....	11·50	2·00	1·50	15·00	....	....	7 17 10*
Do. "C"	37	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	3·00	....	....	11·50	2·00	1·50	15·00	....	....	7 17 10*
Do. "D"	38	do.	do. do.	3·00	....	....	....	11·00	2·00	1·00	14·00	....	....	8 6 3*
5. NITROGEN, PHOSPHORIC ACID AND POTASH.														
Potato Manure, "A"	3	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	..	2·50	..	..	10·00	1·75	1·25	13·00	5·00	..	9 15 7*
Do. "A"	12	ML in diamond	do. do.	....	2·50	....	....	10·00	1·75	1·25	13·00	5·00	....	9 15 7*
Do. "A"	21	C.S.M.L.	do. do.	....	2·50	....	....	10·00	1·75	1·25	13·00	5·00	....	9 15 7*
Do. "A"	36	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	2·50	..	..	10·00	2·00	1·00	13·00	5·00	..	9 15 7*
Do. "AM"	4	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	..	2·50	..	..	11·00	1·75	1·25	14·00	..	5·00	9 15 7*
Do. "AM"	13	ML in diamond	do. do.	....	2·50	....	....	11·00	1·75	1·25	14·00	....	5·00	9 15 7*
Do. "AM"	22	C.S.M.L.	do. do.	....	2·50	....	....	11·00	1·75	1·25	14·00	....	5·00	9 15 7*
Tomato Manure	28	do. ..	do. do.	..	3·50	..	..	9·00	1·50	1·00	11·50	..	8·00	11 12 3*
Tobacco Fertiliser No. 5	30	do.	do. do.	2·80		..	..	10·87	1·88	1·25	14·00	2·50	..	8 19 4*

* On Rail at Works.

FERTILISERS—*continued.*

Name of Fertiliser.	Reg. No.	Brand.	By Whom Registered.	Nitrogen (N) as				Phosphoric Acid (P_2O_5) as				Potash (K_2O) as		Cash Price per ton on Rail at Works or Perth.
				Nitrate.	Ammonia.	Blood and Bone.	Bone Dust.	Water Sol.	Citrate Sol.	Acid Sol.	Total.	Sulphate.	Muriate.	
				%	%	%	%	%	%	%	%	%	%	£ s. d.
6. MISCELLANEOUS.														
Super. and Copper, No. 1	5	Sickle	Cuming Smith & Mt. Lyell F.F., Ltd.	....	....	....	....	13·00	2·50	1·50	17·00	....	....	7 18 8*
Do. No. 2	6	do.	do. do.	....	....	....	....	12·00	2·50	1·50	16·00	....	....	10 13 9*
Do. No. 1	14	ML in diamond	do. do.	....	....	....	....	13·00	2·50	1·50	17·00			7 18 8*
Do. No. 2	15	do.	do. do.	....	....	....	....	12·00	2·50	1·50	16·00	....	....	10 13 9*
Do. No. 1	23	C.S.M.L.	do. do.	....	....	....	....	13·00	2·50	1·50	17·00	....	....	7 18 8*
Do. No. 2	24	do.	do. do.	....	....	....	....	12·00	2·50	1·50	16·00	....	....	10 13 9*
Super. and Copper	35	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	....	....	....	13·00	2·50	1·50	17·00	....	....	7 18 8*
Liquid Manure	52	Faulding's	F. H. Faulding & Co., Ltd.	7·0		....	....	4·50	....	....	4·50	3·50		3s. per pint§
B.—ORGANIC.														
(*a*) *Blood and Bone:*														
Blood and Bone	42	A.N.A. Surprise	C. A. Kirkby & Sons	...		5·00			1·00	10·00	14·00			13 17 6†
Do. do.	43	Eclipse ...	West Australian Meat Exports			6·00				12·00	12·00	...	....	10 9 3*
Do. do.	44	Robb's	do. do.	....	....	5·25	....	....	....	14·00	14·00	....	....	10 4 3*
Do. do.	45	Albany Freezing Works	Albany Freezing Works, Ltd.	....	....	6·00	....	....	....	12·00	12·00	....	....	10 0 0*
Do. do.	48	D.B.G.	W. Angliss & Co. (Aust.) Pty., Ltd.	....	....	7·00	....	....	9·00	2·00	11·00	....	....	9 15 08
Do. do.	49	Premier	do. do.	....	....	7·00	....	....	6·50	5·50	12·00	....	....	10 0 0M
Do. do.	50	Fitzroy	do. do.	....	....	5·00	....	....	13·00	5·00	18·00	....	....	9 10 0M
Do. do.	55	Apollo	J. Kitchen & Sons Pty., Ltd.	....	....	7·00	....	....	4·00	10·00	14·00	....	....	13 0 0F
Animal Fertiliser	47	State Abattoirs, Midland Jct.	State Abattoirs, Midland Junction	....	....	8·00	....	....	....	5·00	5·00	....	....	9 5 0*
(*b*) *Nitrogenous.*														
Dried Blood	51	Fitzroy	W. Angliss & Co. (Aust.) Pty., Ltd.	....	....	13·00	....	....	....	....	....	....	....	13 0 0M
Do.	54	Cresco	Cresco Fertilisers (W.A.), Ltd.	....	....	10·50	....	....	....	1·50	1·50	....	....	13 0 0‖
(*c*) *Miscellaneous:*														
‡Garden Fertiliser	46	Sprout-em	Kag Manufacturing Co.	...	....	5·00	...	...	5·00	4·00	9·00	...	...	...
Fish Fertiliser	56	Cormo	Norwest Fertilisers	....	....	5·00		....	....	8·00	8·00	....	....	....

* On rail at Works. † On rail at Perth. ‡ Made from Bone Phosphate, Casein, and Nutmeal. §Analysis percentage weight for weight.
S F.O.B., Sydney. M F.O.B., Melbourne, F On wharf, Fremantle. ‖ Retail price,

Government Certified Subterranean Clover Seed.

QUALITY OF 1943-44 CROP.

G. R. W. MEADLY.

When purchasing seeds, close attention should be paid to three properties, viz., strain, purity and germination and subterranean clover seed provides no exception to this generality. Consideration of strain is very important as the mid-season and late types will not persist under short-season conditions which are suitable for the early types such as Dwalganup. Again, it is inadvisable to sow the early types in districts favourable for the later strains which remain green longer and tend to produce a greater bulk of feed. Failures with mid-season (Mt. Barker) in the lighter rainfall districts convinced some farmers that they could not grow subterranean clover successfully but many of them now have large flourishing areas of the early maturing Dwalganup.

Seed containing a high proportion of impurities such as grit, stick fragments, manure, etc., is also a possible carrier of weed seeds and the eggs of insect pests. Seeds of many weeds, including cape tulip and double gee have been detected in such lines, and pests such as red mite and lucerne flea are unquestionably transported in this manner. Often these low grade lines are sold at what appears to be a cheap price but a test for purity and germination usually dispels any ideas of economy irrespective of the weed and insect aspects. It is scarcely necessary to say that for productive purposes a seed only has value while it retains its vitality. A low germination, besides producing less plants, is usually associated with weak seedlings and this lack of seedling vigour can prove of considerable consequence when seed bed conditions are not favourable.

The certification of subterranean clover seed by the Department of Agriculture has been designed to ensure that the specific strain required can be purchased but also gives attention to the pure seed content and viability. The various strains cannot be identified with certainty from the seeds alone, but it is possible to determine them when they are growing. Pastures are therefore inspected during the growing period and areas suitable for the production of certified seed of a particular strain are mapped and registered. Later in the season, after the seed gathered from these areas has been threshed, cleaned and graded, samples taken from each bag are tested for purity and if these reach the required standard the necessary tags and slips are provided and the bags are sealed. The samples are then forwarded to the Seed Testing Station where a series of germination tests are conducted. The seal is a guarantee of strain and purity while any purchaser can obtain germination figures by referring the certificate number on the bag to the Department of Agriculture.

During the 1943-44 season subterranean clover seed was certified on behalf of 14 different producers and the table on page 392 summarises the results of germination tests carried out in connection with the scheme.

Several aspects of these figures call for comment. In the main the seed produced was of a high standard and in several cases left little room for improvement. The 58 samples tested on behalf of producer A represented 28 tons of cleaned seed, the purity of which averaged more than 99 per cent. with a germination of 98.5 per cent. The uniformity of the product can be gauged by the fact that none of the

samples gave a germination of less than 94 per cent. The 37 tons and 15 tons of seed cleaned by producers C and E also represented large quantities of high quality seed.

Producer.	Strain.	Tests.	Germination.			Hard Seeds.			Dead Seeds.	Broken Seedlings.
			Highest	Lowest.	Average.	Highest.	Lowest.	Average.		
			%	%	%	%	%	%	%	%
A	Dwalganup	58	100	94	98·5	4	0	0·8	0·2	0·5
B	do.	5	99	94	96·6	5	1	1·8	1·6	....
C	do.	90	100	76	93·8	24	0	5·7	0·2	0·3
D	do.	2	94	93	93·5	6	5	5·5	1·0	....
E	do.	24	98	86	92·9	13	2	6·6	0·1	0·4
F	do.	39	99	71	88·2	24	0	9·4	1·8	0·6
G	do.	12	99	65	87·0	34	1	12·0	0·5	0·5
H	do.	9	98	79	86·7	21	1	12·6	0·2	0·5
I	do.	3	86	83	84·0	16	13	14·0	1·0	1·0
J	do.	16	87	59	71·4	39	12	27·1	1·4	0·1
K	do.	4	67	54	62·8	46	32	36·0	1·0	0·2
I	Midseason (Mt. Barker)	28	98	75	90·4	24	1	6·5	1·9	1·2
L	do.	20	98	64	82·4	23	0	3·5	12·5	1·6
M	do.	24	88	61	74·0	20	3	8·8	13·8	3·4
N	Tallarook ...	2	84	80	82·0	2	1	1·5	15·0	1·5

The relatively low germinations were not due entirely to dead seeds, in several cases hard seeds forming the greater part of the balance. This is particularly apparent in the case of producers J and K where germinations of 71.4 per cent. and 62.8 per cent. are associated with hard seed figures of 27.1 per cent. and 36.0 per cent. respectively. Hard seeds, which occur in many clovers and other legumes, do not absorb moisture readily and may remain in the soil in a dormant condition for a number of years. In an established pasture they represent a safeguard against the effects of malting due to unseasonal rains, but when the farmer himself is able to regulate the time of sowing and looks for a maximum germination a high hard seed content is undesirable.

This characteristic is inherent in subterranean clover and an average of approximately 75 per cent. of the seed crop in this State falls in the "hard" category. The reduction of this high figure is due mainly to the scarifying effect of the machining processes, especially in the "decoater" used for removing the white "coats" or pods which enclose the seed. The efficiency of this machine for decreasing the hard seed content is widely recognised and often seeds devoid of "coats" are passed through it for the specific purpose of increasing the proportion of immediately germinable seeds. High hard seed figures can usually be traced to cleaning operations not including a "decoater" or to the use of a machine incorrectly adjusted.

A relatively low germination associated with a high dead seed content causes more concern. Although this sometimes results from the presence of malted seeds due to unseasonal summer rains, the main damaging agent is fire. In order to eliminate the dry roughage of straw, etc., to facilitate gathering many producers burn the areas to be harvested. In the case of the early (Dwalganup) strain most of the burrs are buried and the seed is seldom appreciably damaged by burning the paddocks. The mid-season (Mt. Barker) and later strains, however, develop a large proportion of their burrs on or near the surface, especially on the heavier soils and where an abundant top growth is allowed to develop. The risk of damage is therefore greatly accentuated, especially if rushes, manure, dry sticks, etc., occur freely as they ignite and destroy the viability of the seed in their vicinity. Pro-

ducers L and M burn their mid-season pastures, and the charred smell of the samples along with the obviously burnt seeds present leave no doubt that the 12.5 per cent. and the 13.8 per cent. of dead seeds were due largely to burning.

The alternatives for removing the roughage are mowing, raking or heavy grazing when dry. These methods have been employed with success, but some producers claim they cannot adopt them, firstly because their paddocks are not sufficiently free of stumps to use a mower or rake, secondly they are too large to ensure close grazing and thirdly mowing is too costly. These are very debatable points, and the farmers outlook is often influenced by whether he regards seed production as a major operation or merely a side line.

If the producer decides that burning cannot be avoided, every care should be taken to minimise the risk of damaging the seed. The area to be gathered should be grazed to reduce the amount of top growth and thus moderate the fire. Usually, burning is carried out in the evening but some growers favour an early morning burn when the ground and roughage are cool and often moistened by dew. Producer I observes these precautions, grazing heavily when dry and burning in the early morning. Besides utilising a quantity of feed which would otherwise be destroyed the average germination of his seed is the highest for the 1943-44 certified mid-season crop. There is little difference between the germination capacity of the Dwalganup and mid-season seed marketed by this grower.

Burnt seeds should be removed as far as possible by crushing, winnowing and grading. They are more brittle than the sound seeds and with perseverance and careful adjustment of the machines a large proportion can be removed in this way. To secure a first grade sample, however, much work is entailed and a quantity of sound seed is inevitably lost. Adopting the methods mentioned to prevent burning the seed may prove tedious but the same can certainly be said concerning the removal of burnt seed from a badly damaged line.

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Agricultural Broadcasts.

The following programme of Agricultural Talks has been arranged for the January-March quarter and will be broadcast from Station 6WA at 9·15 p.m. each Thursday.

Date.	Talk Prepared by :	Title.	Summary.
	I.—FARMERS IN A CHANGING WORLD.		
Jan. 11	E. J. Underwood, Animal Nutrition Officer, Department of Agriculture	Is Modern Technology a Threat to Agriculture ?	The possible effects on agriculture of modern technological trend in synthetic fibres and foods will be discussed.
Feb. 8	M. Cullity, Superintendent of Dairying, Department of Agriculture	Dairying in New Zealand	A comparison with conditions in Western Australia.
Mar. 8	G. H. Burvill, Assistant Plant Nutrition Officer, Department of Agriculture	Settlement Possibilities on the Ord River	Discussion of the physical features, soils, and climate of the lower Ord River valley by a member of a soil survey party recently working in that area.
	II.—TOPICAL ITEMS.		
Jan. 18 Feb. 15 Mar. 15	G. K. Baron Hay, Under-Secretary for Agriculture will discuss current events in Agriculture		
	III.—FARMERS' FORUM.		
Jan. 25 Feb. 22 Mar. 22	Discussion on subjects submitted by farmers is arranged by G. A. Currie, Professor of Agriculture, University of Western Australia		
	IV.—TECHNICAL TALKS.		
Jan. 4	G. R. W. Meadly, Assistant Government Botanist, Department of Agriculture	Our Weed Problems—Cape Tulip	The significance of this weed in Western Australia, together with control measures, will be discussed.
Feb. 1	C. F. H. Jenkins, Government Entomologist, Department of Agriculture	Some Orchard Pests	The life history and importance of a number of orchard pests will be outlined together with suitable control measures.
Mar. 1	W. P. Cass Smith, Plant Pathologist, Department of Agriculture	Common Diseases of Wheat	A brief account of the chief diseases of wheat in Western Australia and appropriate methods of control.
Mar. 29	E. T. Morgan, Officer-in-Charge, Potato Branch	The use of Tuber-Unit Plots in the Production of Seed Potatoes	A description will be given of this method of seed potato production which enables symptoms of virus disease more readily to be detected.

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